Fishery Data Series No. 99-37

Surveys and Stock Monitoring of Rainbow and Steelhead Trout in the Upper Copper River Drainage During 1998

by
Douglas F. Fleming

December 1999

Alaska Department of Fish and Game **Division of Sport Fish**

Symbols and Abbreviations

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Weights and measures (metric)

centimeter	cm
deciliter	dL
gram	g
hectare	ha
kilogram	kg
kilometer	km
liter	L
meter	m
metric ton	mt
milliliter	ml
millimeter	mm

Weights and measures (English)

cubic feet per second	ft^3/s
foot	ft
gallon	gal
inch	in
mile	mi
ounce	oz
pound	lb
quart	qt
yard	yd

Spell out acre and ton.

Time and temperature

day	d
degrees Celsius	°C
degrees Fahrenheit	°F
hour (spell out for 24-hour clock)	h
minute	min
second	s

Spell out year, month, and week.

Physics and chemistry

all atomic symbols	
alternating current	AC
ampere	A
calorie	cal
direct current	DC
hertz	Hz
horsepower	hp
hydrogen ion activity	pH
parts per million	ppm
parts per thousand	ppt, ‰
volts	V
watts	W

General

All commonly accepted abbreviations.	e.g., Mr., Mrs., a.m., p.m., etc.
All commonly accepted professional titles.	e.g., Dr., Ph.D., R.N., etc.
and	&
at	@
Compass directions:	
east	E
north	N
south	S
west	W
Copyright	©
Corporate suffixes:	
Company	Co.
Corporation	Corp.
Incorporated	Inc.
Limited	Ltd.
et alii (and other people)	et al.
et cetera (and so forth)	etc.
exempli gratia (for example)	e.g.,
id est (that is)	i.e.,
latitude or longitude	lat. or long.
monetary symbols (U.S.)	$, ¢
months (tables and figures): first three letters	Jan,...,Dec
number (before a number)	# (e.g., #10)
pounds (after a number)	# (e.g., 10#)
registered trademark	®
trademark	™
United States (adjective)	U.S.
United States of America (noun)	USA
U.S. state and District of Columbia abbreviations	use two-letter abbreviations (e.g., AK, DC)

Mathematics, statistics, fisheries

alternate hypothesis	H_A
base of natural logarithm	e
catch per unit effort	CPUE
coefficient of variation	CV
common test statistics	F, t, χ^2, etc.
confidence interval	C.I.
correlation coefficient	R (multiple)
correlation coefficient	r (simple)
covariance	cov
degree (angular or temperature)	°
degrees of freedom	df
divided by	÷ or / (in equations)
equals	=
expected value	E
fork length	FL
greater than	>
greater than or equal to	≥
harvest per unit effort	HPUE
less than	<
less than or equal to	≤
logarithm (natural)	ln
logarithm (base 10)	log
logarithm (specify base)	log_2, etc.
mideye-to-fork	MEF
minute (angular)	'
multiplied by	x
not significant	NS
null hypothesis	H_O
percent	%
probability	P
probability of a type I error (rejection of the null hypothesis when true)	α
probability of a type II error (acceptance of the null hypothesis when false)	β
second (angular)	"
standard deviation	SD
standard error	SE
standard length	SL
total length	TL
variance	Var

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SURVEYS AND STOCK MONITORING OF RAINBOW AND STEELHEAD TROUT IN THE UPPER COPPER RIVER DRAINAGE DURING 1998

by

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TABLE OF CONTENTS

Page

LIST OF TABLES

Table **Page**

LIST OF FIGURES

Figure **Page**

LIST OF APPENDICES

Appendix **Page**

ABSTRACT

Rainbow and steelhead trout studies were initiated in 1998 in the Upper Copper Upper Susitna Management Area which is located in South Central Interior Alaska. Surveys and sampling were conducted at three locations in the Copper River drainage: the Gulkana, Tazlina and Hanagita drainages. These studies collected information on rainbow and steelhead trout in terms of presence, spawning concentrations and, age and size information. Riverine habitat was described in general terms so that information is available for planning future stock assessment studies.

During spring sampling we found seven resident rainbow and two steelhead trout in one spawning area in the middle fork Gulkana near Dickey Lake, and approximately 150 previously constructed redds. Along Hungry Hollow Creek, 17 resident rainbow and seven steelhead trout were tagged and sampled. In a sampling trip during the summer feeding period, 55 trout were caught. The size composition of these fish suggested that catch-and-release regulations have been effective at increasing average length of rainbow trout in the Gulkana River, even though there have been increasing numbers of anglers each year.

At Kaina Creek in the Tazlina River drainage, a 21 mi survey was conducted, and spawning rainbow and steelhead were observed. Few fish were sampled but recently constructed redds were present which suggested trout may have spawned prior to our survey.

In the Hanagita River drainage, immigrating steelhead trout were sampled in an attempted mark-recapture experiment. Sampling and tagging were conducted on fall-run steelhead. Only 10 steelhead were sampled. An estimate of abundance could not be generated. In the course of the study we observed pre-spawning adult steelhead farther up the Hanagita River drainage than previously recorded. The observed geographic distribution of Hanagita steelhead was different from observations in previous years in that fish were not concentrated near inlets to, and the outlet from, Hanagita Lake. It is likely that these changes in geographic distribution of steelhead within the drainage created concerns over the population status and led to a decline in the sport fishery, which historically targeted fish holding near inlets and the outlet of Hanagita Lake.

Key Words: Rainbow trout, steelhead trout, *Oncorhynchus mykiss,* Copper River drainage, Gulkana River, Tazlina River drainage, Kaina Creek, Hanagita River, length composition, age composition.

INTRODUCTION

Rainbow and steelhead trout *Oncorhynchus mykiss* populations that inhabit the Upper Copper Upper Susitna drainages are considered the northernmost wild stocks of this species in North America. Stock is defined here as that component of the population that is vulnerable to angling. Any alternative biological-or management-based definition is premature at this time because attributes characterizing the biology and exploitation are unknown. Rainbow trout populations in this area are resident (year-round presence), and may seasonally break into smaller spawning aggregates. Steelhead trout in this region are believed to have a fall-run timing for migration from the ocean to freshwater, and aggregate into spawning stocks. Exploitation during migrations from the ocean occurs as incidental harvest during commercial salmon fisheries, from subsistence and personal use fisheries along the mainstem Copper River, and sport fisheries at or near spawning locations in Copper River tributaries.

Similar to other salmonid species living at the edges of their distribution (Flebbe 1994), these stocks are relatively sparse and unproductive. The large size of the upper Copper River drainage, the small stock sizes, and the seasonal migration patterns, have constrained our knowledge of the distribution of wild rainbow and steelhead trout in this area. The larger, more productive stocks have been detected and exploited by anglers, particularly in areas that are easily accessed.

Rainbow trout and steelhead are known to be within the Gulkana River drainage, which annually hosts thousands of recreationists boating the nationally designated “Wild River” (Figure 1).

Rainbow trout were captured during chinook salmon *O. tshawytscha* escapement surveys on Kaina Creek (Craig Whitmore, ADF&G, Palmer, personal communication), and steelhead were tracked to Kaina Creek during a Copper River steelhead radio telemetry study (Burger et al. 1983). Within the Wrangell-St Elias National Park, rainbow trout and steelhead exist in lakes and rivers of the Tebay River drainage. These three locations of the Upper Copper drainage are subjected to varying use levels by anglers. Since 1990, catches and harvests of rainbow trout have been reported in other Upper Copper tributaries such as the Tonsina and Klutina rivers (Mills 1991-1994, Howe et al. 1995-1997), and other smaller Copper Basin streams including Mendeltna Creek (Mills 1993, 1994) and Tyone Creek (Mills 1993, Howe et al. 1995). Other information, such as individual subsistence harvest reports, anecdotal accounts, and angler responses to the statewide harvest, catch, and participation surveys have indicated that additional populations of rainbow trout and steelhead exist in the Copper River drainage.

In 1987 the Alaska Board of Fish (BOF) approved an amendment to the Cook Inlet Rainbow/steelhead Trout Management Policy (CIRTMP) which extended the geographic coverage of the policy to include the Upper Copper Upper Susitna Management Area (UCUSMA). This policy, renamed the Cook Inlet and Copper River Basin Rainbow/Steelhead Trout Management Policy was developed to provide a framework for rainbow and steelhead trout fishery management. This framework included:

Policy I: Native rainbow trout populations will be managed to maintain historical size and age composition and stock levels; and,

Policy II: A diversity of sport fishing opportunities for wild and hatchery rainbow/steelhead trout will be provided through establishment of special management areas by regulation.

These policies have led to more conservative regulations for stocks (known and unknown) of rainbow and steelhead within the UCUSMA and the creation of special management areas in the Tebay River drainage. In addition to management policies, recommendations were given for research:

1. develop adequate methodologies to estimate rainbow trout abundance and fishing mortality;
2. develop an index of the relative abundance for rainbow /steelhead trout in selected waters;
3. examine spatial and seasonal distribution of rainbow trout in selected waters;
4. characterize size and age composition in selected waters;
5. develop information on the harvest of rainbow trout/steelhead; and,
6. obtain information on angler preferences for management of trout fisheries.

Under the guidance of the BOF-approved policy and recommended research objectives, baseline biological research was initiated in 1998 that focused on rainbow and steelhead trout resources in

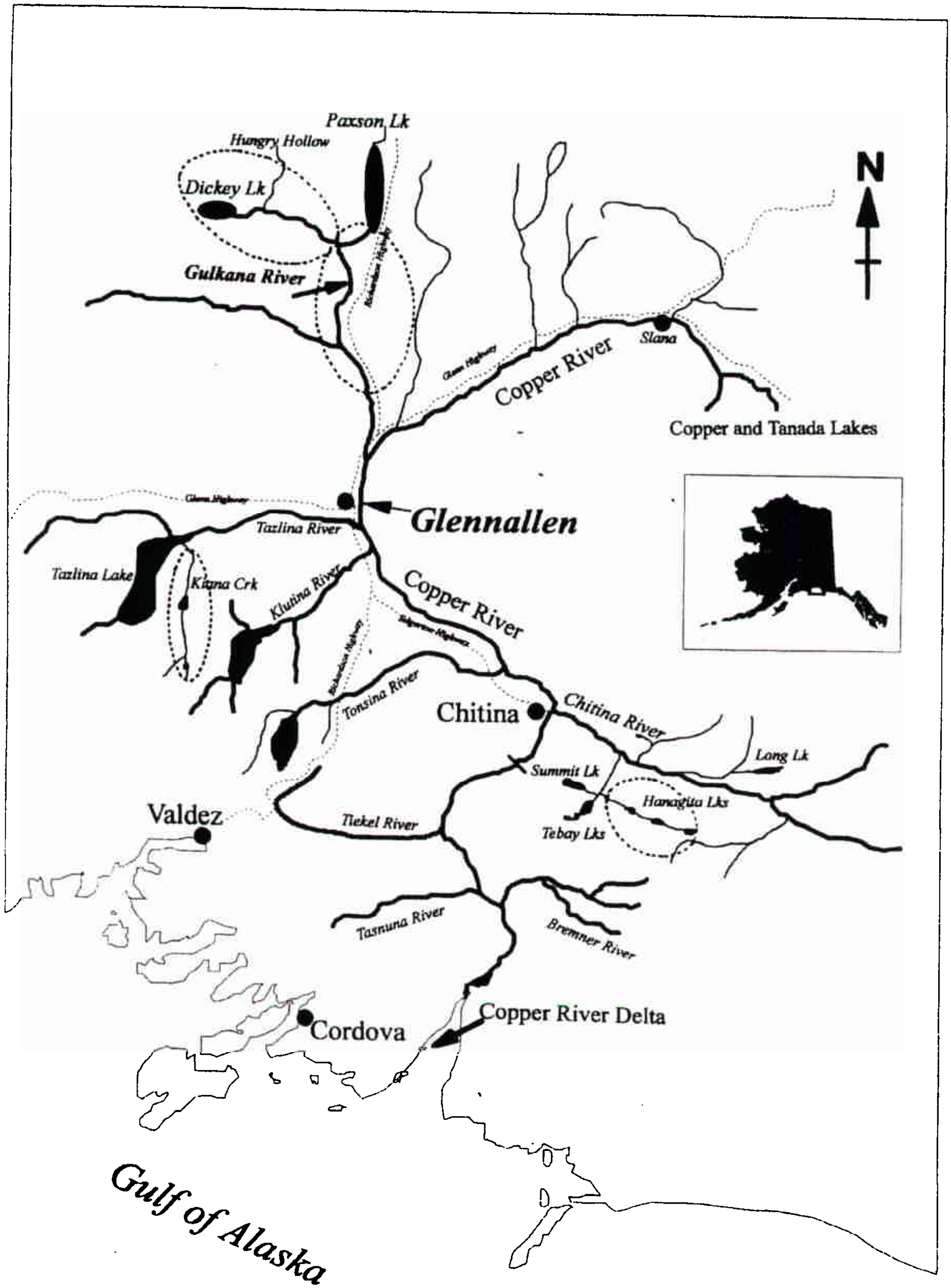

Figure 1.-The Copper River drainage, including locations (circled) of 1998 field investigations.

the Upper Copper River Basin. These studies were designed to give managers current information on several rainbow and steelhead trout stocks, to provide information for designs of future stock assessment, and to provide anglers with updated and enhanced information on rainbow and steelhead trout fishing opportunities.

Gulkana River Drainage

The Gulkana River drainage is the largest recreational fishery in the UCUSMA, and accounts for as much as 50% of the area's total annual estimated angling use days (Mills 1979-1994, Howe et al. 1995-1998). This drainage supports the largest known rainbow trout and steelhead (Table 1), chinook salmon, and Arctic grayling sport fisheries within the management area (Szarzi 1996). Following the 1987 BOF-approved management policy, rainbow and steelhead bag limits were markedly reduced. Bag limits changed from 10 fish per day, 10 in possession, with only two fish over 20 in to two per day, two in possession, with only one fish over 20 in. By 1990, managers believed the rainbow and steelhead trout population had declined and the stock could not sustain continued harvests (Szarzi 1996). Beginning in 1991, the rainbow and steelhead trout fishery in the Gulkana River has been managed by catch-and-release regulation, with progressively more gear restrictions in upstream areas where resident rainbow are frequently encountered. Since that time anglers have been restricted to the use of unbaited artificial lures, from the Gulkana's headwaters in the Alaska Range downstream to the canyon area (Figure 2). Below the canyon area, anglers can use bait downstream of a marker located about 7.5 mi[1] upstream of the West Fork of the Gulkana River. Since 1988, estimated angling effort on flowing waters within the drainage (Figure 3) has increased (Mills 1979-1994, Howe et al. 1995-1998). The annual average estimated effort from 1977 through 1990 was approximately 13,700 angler-days. From 1991 through 1997, the average estimated effort in the Gulkana River was approximately 28,000 angler-days (Table 1). Angler effort did not decline following restrictive gear regulations in the upper river. Estimates of angling effort in the commonly floated portion of the mainstem between Paxson Lake and Sourdough have continued to climb from roughly 3,000 angler-days in the late 1980's to over 14,000 in 1997 (Mills 1979-1994, Howe et al. 1995-1998).

In 1997, the BOF passed further restrictions that closed portions of the Middle Fork of the Gulkana to all angling during periods of rainbow and steelhead trout spawning and part of the egg incubation period. This closure runs from April 15-June 14, and includes portions of the Middle Fork from Dickey Lake downstream approximately 3 mi and all of Hungry Hollow Creek. The most current observations (1993-1995) on the steelhead spawning population in the Middle Fork of the Gulkana indicated that as few as 20-30 anadromous steelhead were on spawning beds with resident rainbow trout from 1993 to 1995 (Stark 1999). In 1996, 46 post-spawning steelhead (kelts) were passed downstream over a resistance-board weir between June 11 and July 31 on the Gulkana River near Sourdough (LaFlamme 1997). This represented a

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[1] For the purposes of this report, distances and elevations describing geography, habitat, and angling regulations are in English units of measure. Estimates of fish lengths, such as in composition estimates, are in metric units.

Table 1.-Yearly effort[a], harvest[b], and catch of wild rainbow trout and steelhead by sport anglers fishing the Gulkana River from 1977-1996.

		Rainbow trout		Steelhead trout	
Year	Effort	Harvest	Catch	Harvest	Catch
1977	4,165	752	---	0	---
1978	6,570	1,256	---	0	---
1979	17,323	1,455	---	0	---
1980	13,752	1,249	---	0	---
1981	14,430	1,469	---	0	---
1982	14,979	1,257	---	52	---
1983	16,911	1,341	---	21	---
1984	12,870	1,266	---	0	---
1985	14,080	2,098	---	137	---
1986	14,219	1,104	---	18	---
1987	17,354	1,517	---	104	---
1988	11,299	1,218	---	18	---
1989	15,285	656	---	47	---
1990	18,782	425	2,395	34	68
1991	20,944	150	1,133	0	26
1992	25,650	16	1,654	8	39
1993	27,034	40	2,724	0	102
1994	25,357	0	3,380	0	0
1995	32,656	0	3,958	0	0
1996	34,738	0	7,932	0	0
1997	31,831	0	5,852	0	69

[a] Estimates of angling effort included the Gulkana River only, and do not include effort within lakes. Effort is angler days.

[b] Estimates of harvest included fish harvested at Paxson Lake; the rainbow trout fishing and harvests occur in the outlet area.

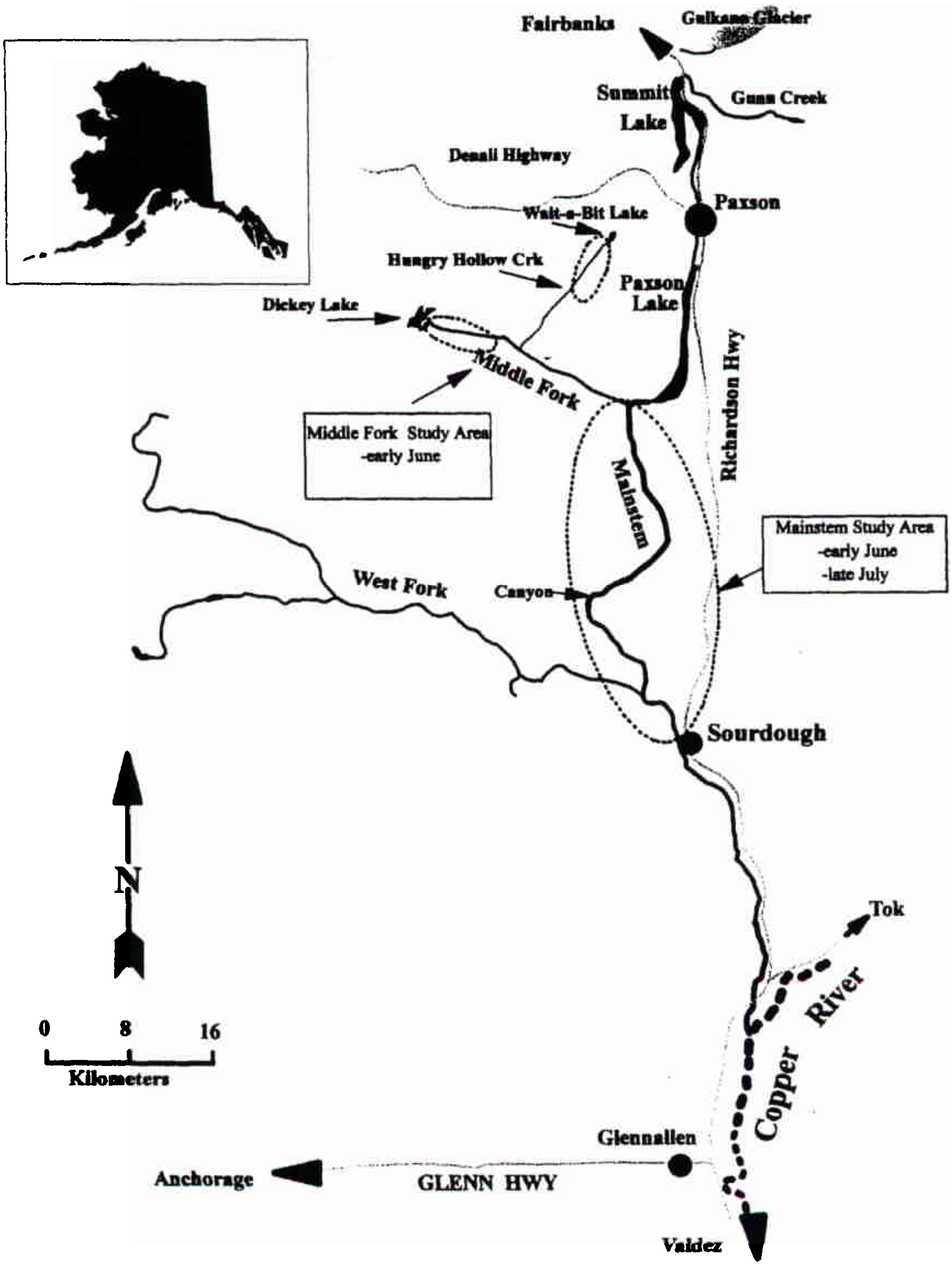

Figure 2.-The Gulkana River drainage including locations (circled) of 1998 field investigations at spawning locations along the Middle Fork and Mainstem Gulkana River.

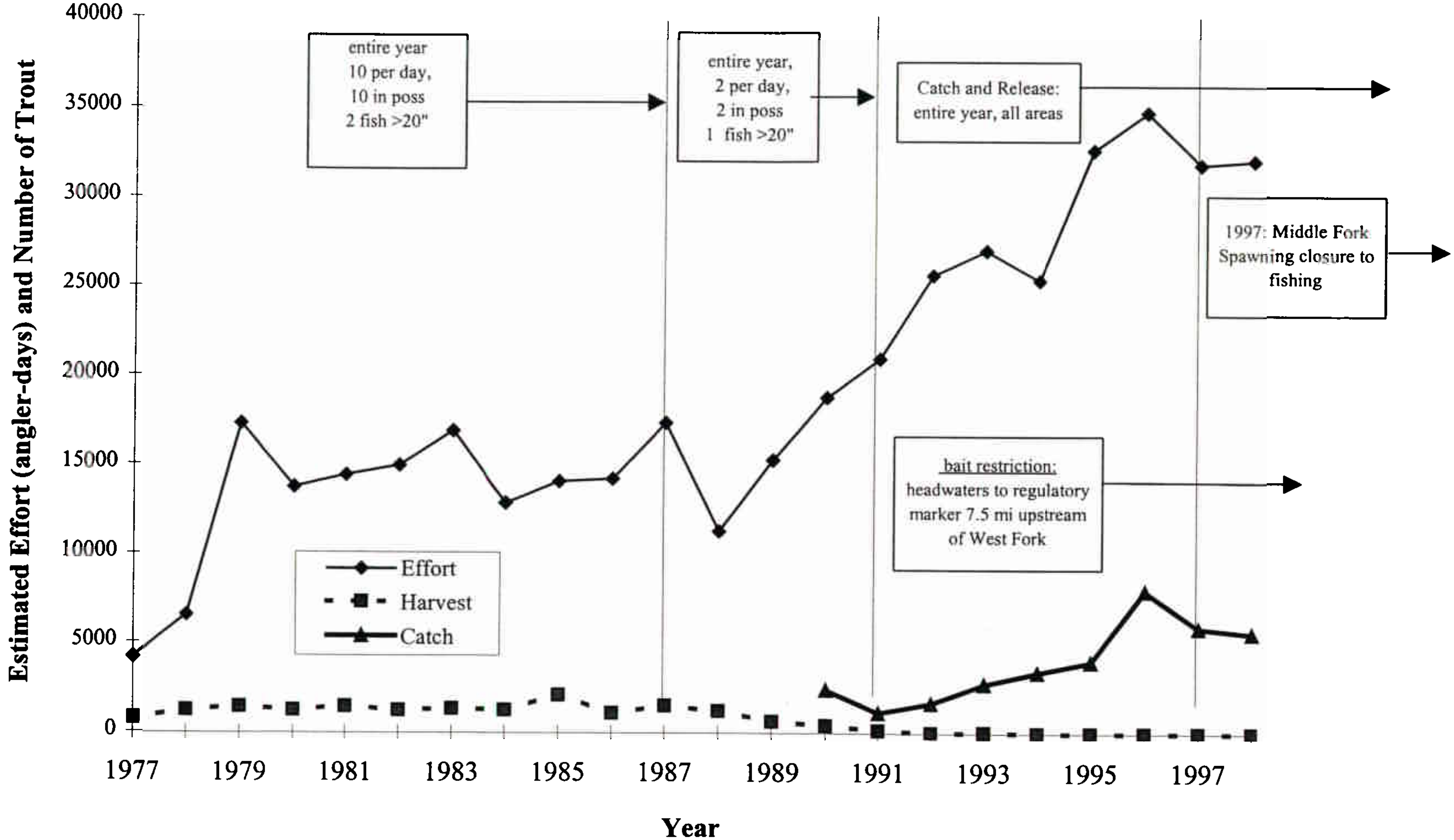

Figure 3.-Estimates of angling effort, harvests, and catches of rainbow trout and fishing regulations within the Gulkana River drainage, 1977-1998.

minimum estimate since anglers have reported catching post-spawning steelhead earlier than this time in the lower portion of the Gulkana River while fishing for chinook salmon. Historical harvest estimates (ADF&G *Unpublished b*) have ranged from 0 to 137 steelhead. (This information is from low numbers of responses to the statewide harvest survey and should be viewed with caution). In 1984, the Alaska Department of Fish and Game (ADF&G) and the U.S. Bureau of Land Management staff conducted helicopter and stream surveys that resulted in count estimates of approximately 200 steelhead using the known spawning reaches within the Middle Fork Gulkana drainage (Williams and Potterville 1985). These may have been gross counts of rainbow trout and steelhead combined.

Angling catch estimates (Howe et al. 1996, 1997) of rainbow trout doubled between 1995 and 1996, with only a slight (6%) increase in estimated effort (Figure 3). The resident rainbow trout population may have responded favorably to the conservative regulations.

Tazlina River Drainage

In 1983, radio tagged steelhead trout were tracked from fall through the early June spawning period in tributaries to the upper Copper River (Burger et al. 1983). These fish were captured, radio tagged, and released in the mainstem Copper River during September 1982. Of the 17 fish that were successfully tracked through the winter, eight fish used the Tazlina drainage, and nine fish traveled further upstream to the Gulkana drainage (Burger et al. 1983). Based on limited tracking and assumed times for spawning, six fish were presumed to have spawned in the Tazlina River drainage. Of these fish, two were located within the Kaina Creek drainage at the perceived time of spawning, and two other fish may have spawned there based on their last known locations in Tazlina Lake and River. The other remaining fish were tracked to two small tributaries (8-Mile and Durham Creeks) and the lower Tazlina River (Tazlina River mile 0.5) at the time of spawning (Burger et al. 1983).

Kaina Creek provides optimal habitat for salmonid spawning, particularly chinook and sockeye salmon *O. nerka* (Roberson 1986). The drainage has two lakes, Upper Kaina Lake and Kaina Lake, and these are connected by Kaina Creek, which flows approximately 30 mi before entering Tazlina Lake. This drainage hosts resident populations of rainbow trout, lake trout *Salvelinus namaycush*, Arctic grayling *Thymallus arcticus*, burbot *Lota lota*, and Dolly Varden *S. malma* (ADF&G *Unpublished a*). No biological data has been collected on these stocks other than stream, lake, and broodstock surveys conducted in the early 1960s and 1980s. Estimates (ADF&G *Unpublished b*) taken from statewide angling harvest and catch surveys indicate anglers fly to Kaina Lake to fish for resident species and fly to Kaina Creek's outlet into Tazlina Lake to fish for chinook salmon. Estimates (ADF&G *Unpublished b*) for rainbow trout harvests ranged from 0 to 100 fish annually, and catches ranged from eight to 700 fish. (This information is from low numbers of responses to the statewide harvest survey and should be viewed with caution).

Hanagita River Drainage

Within the Tebay River drainage (Figure 1), rainbow stocks inhabit the headwater lakes of the Tebay and Hanagita rivers, and fall-run steelhead are seasonally present within the Hanagita River and Hanagita lakes. Following adoption of the Cook Inlet and Copper River basin Rainbow/Steelhead Trout Management Policy, the fly-in fisheries in this relatively small drainage were divided into special management areas (i.e., harvest, trophy, and catch-and-release waters) by regulation. Anglers on Upper, Middle, and Lower Tebay lakes are allowed to harvest five fish per day, with only one fish larger than 20 in (>480 mm FL). Summit Lake and Bridge Creek (the outlet creek) were designated as trophy fisheries for large resident rainbows. Anglers are allowed to fish between July 11 and September 20 each year and the bag limit is one rainbow trout larger than 32 in (>810 mm FL). Lastly, anglers seeking steelhead and rainbow trout are restricted to catch-and-release regulations in the lower portion of the Hanagita River drainage. The history of the Hanagita system rainbow and steelhead regulations are:

Period:	Hanagita Lake and River to Tebay River	Upstream of Hanagita Lake[a]
1962-1987	10 fish daily, only 2 fish > 20 in	10 fish, only 2 fish > 20 in
1988-1990	2 fish daily, 2 in possession, only 1 fish > 20 in using only unbaited single-hook artificial lure	5 fish daily, 5 in possession, only 1 fish > 20 in
1991 - present	catch-and-release only, using only unbaited single-hook artificial lure	5 fish daily, 5 in possession, only 1 fish > 20 in

[a] This area's regulation is categorized under the "remainder of the (Tebay R) drainage"

Fall-run steelhead fishing occurs in the Hanagita system. Anglers fish in the outlet area of Hanagita Lake and non-glacial portions of the Hanagita River. Little is known about this fishery in terms of history, and past fishery performance. No comprehensive studies have examined the stock in terms of composition, distribution, and abundance. Several visual counts in the mid 1980's, and limited age and length samples collected during the 1960's and 1970's comprise the known information on Hanagita Lake and River. Estimates from annual statewide harvest, catch and participation studies (1986-1997) have indicated low level fishing effort (28 - 619 angling days) takes place, and to date only rainbow trout have been reported in harvests and catches (ADF&G *Unpublished a*). Anecdotal information from anglers, aerial observations from pilots and ADF&G staff, and low estimates of angling use (ADF&G *Unpublished b*) suggested the stock may have been over exploited. St. Elias National Park staff question whether this occurred, and, if steelhead even continue to use the system (Russ Galipeau, Wrangell-St. Elias National Park, personal communication). In 1998, ADF&G initiated field studies on rainbow trout and steelhead in the Hanagita River drainage in accordance with the 1987 Cook Inlet and Copper River Basin Rainbow Trout/Steelhead Management Policy. Collection of baseline biological information on the rainbow trout and steelhead stocks in the Hanagita River was attempted.

OBJECTIVES

The paucity of biological and population monitoring data for populations of rainbow trout and steelhead in the UCUSMA have left managers without benchmark data or criteria for management. Rainbow trout and steelhead field investigations are needed to provide baseline information on stock status and life history. Similar to management and research of Susitna River stocks (Bradley 1991, Rutz 1992), initial field investigations primarily focused on collection of size and age information to generate composition estimates that reflect the stock available to the angling public. Size and age data may eventually be used to describe growth of

Gulkana River stocks in comparison to other Alaskan populations. Tag recovery information from fish tagged in 1998 will help to determine seasonal movements and geographic mixing which will be important in determining methodologies to gauge stock levels. Additionally, information from tagged fish will be used to describe distribution and life history of these resident rainbow and anadromous steelhead stocks.

The research objectives for 1998 were to:

1. estimate the age and length composition of rainbow trout vulnerable to angling from a 30 mi section of Kaina Creek in late-May and early-June;
2. estimate the age and length composition of steelhead trout vulnerable to angling from a 30 mi section of Kaina Creek in late-May and early-June;
3. estimate the age and length composition of rainbow trout vulnerable to angling from spawning concentrations within the Middle Fork of the Gulkana and within a 47 mi section of the mainstem Gulkana River between Paxson Lake and Sourdough in early-June;
4. estimate the age and length composition of steelhead trout vulnerable to angling from spawning concentrations within the Middle Fork of the Gulkana and within a 47 mi section of the mainstem Gulkana River between Paxson Lake and Sourdough in early-June;
5. estimate the age and length composition of rainbow trout vulnerable to angling within a 47 mi section of the mainstem Gulkana River between Paxson Lake and Sourdough in late-July;
6. test the hypothesis that the size compositions of rainbow trout vulnerable to angling in the mainstem Gulkana River during early June were similar to composition estimates taken in late-July in the same area such that a difference of 20% in proportion of large ($\geq$ 480 mm FL) rainbow trout can be detected;
7. estimate the age and length composition of rainbow trout vulnerable to angling within a 6 mi section of the Hanagita River immediately below Hanagita Lake in mid-September;
8. estimate the age and length composition of steelhead trout vulnerable to angling within a 6 mi section of the Hanagita River immediately below Hanagita Lake in mid-September; and,
9. estimate the abundance of rainbow trout and steelhead trout within a 6 mi section of the Hanagita River immediately below Hanagita Lake in mid-September.

METHODS

STUDY AREAS

The Gulkana River is a clear runoff stream that flows southwards out of the Alaska Range and runs 100 mi before reaching the Copper River near Glennallen. The Gulkana currently begins above timberline at Gunn Creek, a tributary to Summit Lake. Originally, waters of the Gulkana

River may have originated within the Gulkana Glacier[2] and flowed through Monument Creek into Summit Lake bearing glacial silts (Allin 1957). Below Summit Lake, the Gulkana River flowed into Gulkana Lake (now known as Paxson Lake) carrying glacial silt. Allin (1957) reported that below Paxson Lake's outlet, the Gulkana River retained a milky glacial color. Presently, glacial outwash from the Gulkana Glacier enters the Delta River drainage, which allows the Gulkana flowing waters to be cleared of suspended glacial silt. The mainstem Gulkana River has two major tributaries, the West Fork (approximately 185 mi in length, including major tributaries) and the Middle Fork (25 mi in length), both of which require remote access by airplane, or combinations of canoeing and overland portaging. Much of the land bordering the river is US Bureau of Land Management (BLM) lands, and much of the river drainage was designated as a National Wild River through the 1980 Alaska National Interest Lands Conservation Act (ANILCA). The Ahtna Native Corporation owns most of the land downstream of Sourdough. Stream habitat within the Gulkana River drainage ranges from slow meandering reaches with sand and silt substrates to high gradient sections of Class III+ rapids in small incised canyons. Within the Middle Fork Gulkana River, rainbow and steelhead trout use a short 3 mi segment of river for spawning and juvenile rearing downstream of Dickey Lake and in Hungry Hollow Creek. The two areas are notably different. The Middle Fork Gulkana immediately downstream of Dickey Lake has a low gradient, and the river is shallow and runs over a mixture of gravel and small cobble substrates. A unique feature below Dickey Lake is the presence of extensive aufeis accumulations where the ice bordering and seasonally covering the river may be 6-9 ft thick. At this site, the amount of riparian vegetation varies seasonally; sparse during spring because of the thick winter accumulations of ice, and thicker in summer following the ice melt. Much of the Gulkana River was described by Albin (1977), more recently by Brink (1995), and later quantified by Stark (1999).

Hungry Hollow Creek drains southward from an area of open tundra near Milepost 10 along the Denali Highway and through a series of small connected ponds and lakes before reaching the Middle Fork of the Gulkana. In the areas used by spawning rainbow and steelhead downstream of Wait-A-Bit Lake, the habitat is primarily composed of large cobble and pool riffle habitat with a moderately high stream gradient. Adjacent to the creek, thick riparian stands of willow *Salix sp.* are the dominant vegetation type mixed with scattered spruce *Picea sp.* Hungry Hollow Creek and the Middle Fork Gulkana downstream of Dickey Lake were first documented as spawning areas in a 1983 radiotelemetry project (Burger et al. 1983). Aerial helicopter counts of as many as 100 steelhead were made in Hungry Hollow and below Dickey Lake during the second year of the steelhead radiotelemetry project (Williams and Potterville 1985). These spawning areas for steelhead and resident rainbow were later sampled and described by graduate students from the University of Alaska Fairbanks who also conducted studies on juvenile habitat, habitat ecology, and spawning stocks of Gulkana River rainbow trout and steelhead (Brink 1995, Stark 1999).

Both Kaina Creek and the Hanagita River are clear water runoff drainages that originate on the northern flanks of the Chugach Mountains. Both systems flow into large glacial tributaries to the

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[2] I was not able to find any evidence that outflow from the Gulkana glacier was diverted by human intervention or natural occurrences. Ideas and recollection by several longtime residents about glacial silt entering Paxson Lake and the Gulkana River were not consistent with Allin (1957).

Copper River, the Tazlina and Chitina drainages. Both systems are remote, with no nearby roads and require floatplane access. In addition to rainbow and steelhead trout, these drainages also host populations of Arctic grayling and lake trout. The land within the Kaina Creek drainage is primarily owned by the State of Alaska, and lands adjacent to the Hanagita River drainage are in a designated wilderness area in the Wrangell-St. Elias National Park.

The Kaina Creek drainage begins at an elevation of 4,700 ft and runs 40 mi before entering Tazlina Lake at an elevation of 1,786 ft (Figure 4). This drainage includes several lakes (Upper Kaina Lake and Kaina Lake) which offer habitat for resident and anadromous fish production (ADF&G *Unpublished a*). The flowing waters are clear and estimated average stream gradients[3] range between 17 and 87 ft per mile (ft/mi) in the 32 mi between Upper Kaina Lake and Tazlina Lake. Stream widths range from 30 to 60 ft wide and depths range to 6 ft. The primary stream habitat surveyed in 1998 included reaches of fast-run and pool-riffle sequences with fine gravel to coarse cobble substrates in the section bounded by an outlet creek from Upper Kaina Lake and the head of an incised canyon 4 mi below Kaina Lakes. Slow flowing and meandering channel habitat with sand to fine gravel substrates are located immediately upstream of Kaina Lake. The remaining portion of Kaina Creek includes swift flows through a small incised canyon with primarily large rocky substrates and finishes with pool-riffle sequences obstructed by many downed cottonwood trees *Populus sp.* before entering Tazlina Lake. Much of the drainage upstream of Kaina Lake is at or above treeline, with willow as a dominant vegetation mixed with scattered spruce. Downstream of Kaina Lake, the vegetation pattern is shifted by additions of riparian stands of cottonwoods.

The headwaters of the Hanagita River drainage include clear and glacial sources that begin on mountain slopes at elevations between 4,000 and 7,000 ft above sea level. Upstream of Sangaina Creek, the Hanagita River is free from glacial silt and flows 22 mi through a series of three lakes (Upper, Middle, and Lower Hanagita lakes), from an elevation of 2,800 ft to 2,000 ft. The source of the clear river is comprised of these lakes, tributary creeks such as Lake Creek, and many small runoff sources draining north and south slopes of adjacent mountain ridges. Estimated average stream gradients upstream of Sangaina Creek range from 13 to 169 ft/mi. In the area of the past sport fishery and at locations where steelhead trout were observed stream gradient is estimated as 55 ft/mi. Stream widths along the Hanagita River range from 30 to 40 ft and average depths from 2-3 ft. Stream habitat has been described as predominately pool-riffle habitat with fine gravel substrates in the outlet area of Hanagita Lake. Previous ADF&G staff have noted that quality spawning habitat (depth, velocity, and gravel) extends downstream approximately 6 mi. This section was selected for the study area in 1998 but later shortened after initial surveys (air and foot) detected high stream gradients and heavy rapids in all but the uppermost 1.5 mi below Hanagita Lake (Figure 5). Below the study area, the river runs 8.5 mi before joining the Tebay River. The Tebay River runs 10 mi through a steep canyon, with estimates of stream gradients as high as 375 ft/mi, before reaching the Chitina River. Above

[3] Estimated average stream gradients were calculated from digitized distances along the stream or river's course between adjacent 50 or 100 foot contour intervals plotted on USGS Topographic maps at 1:63,360 scale.

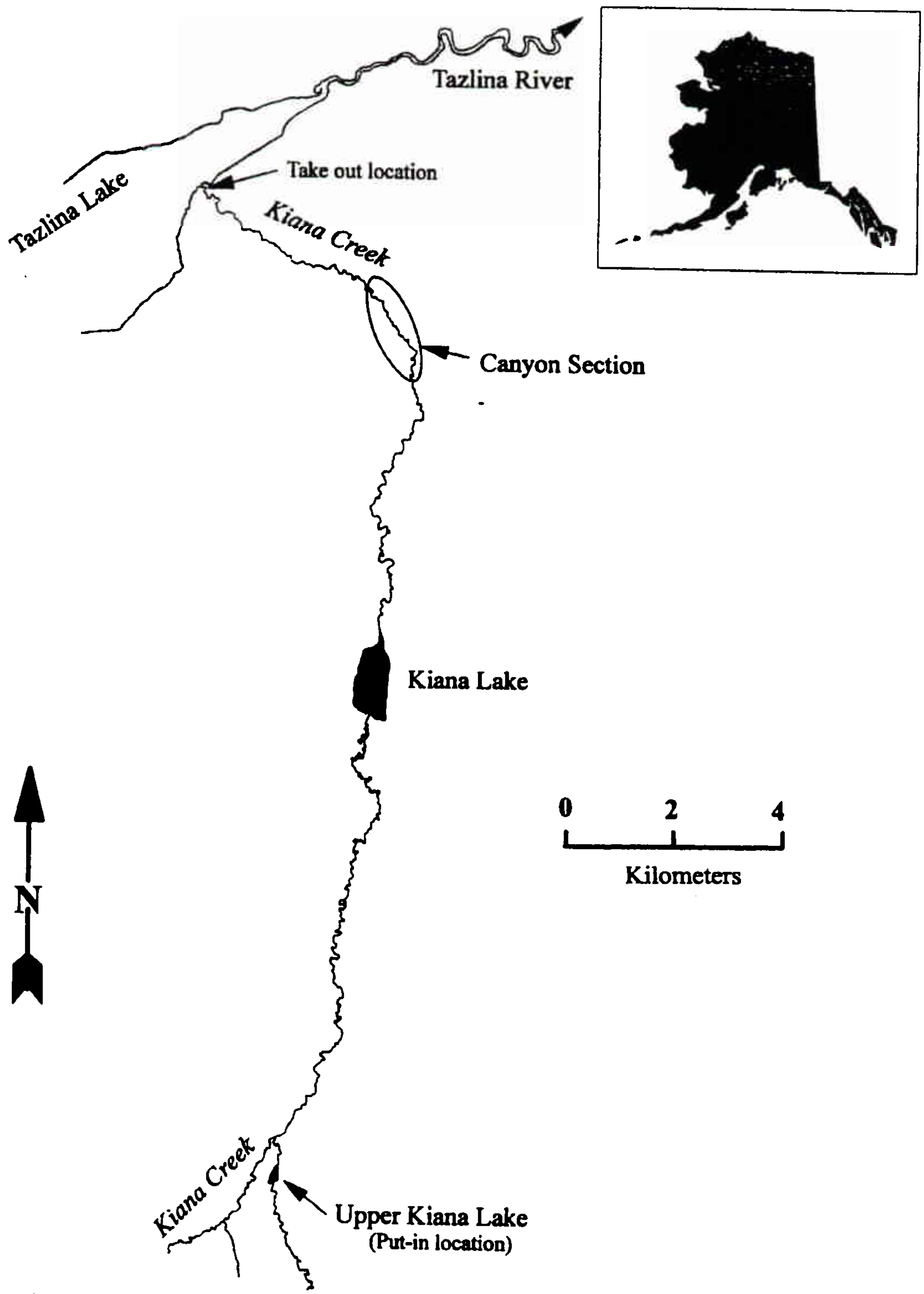

Figure 4.-Map of the Kaina Creek study area.

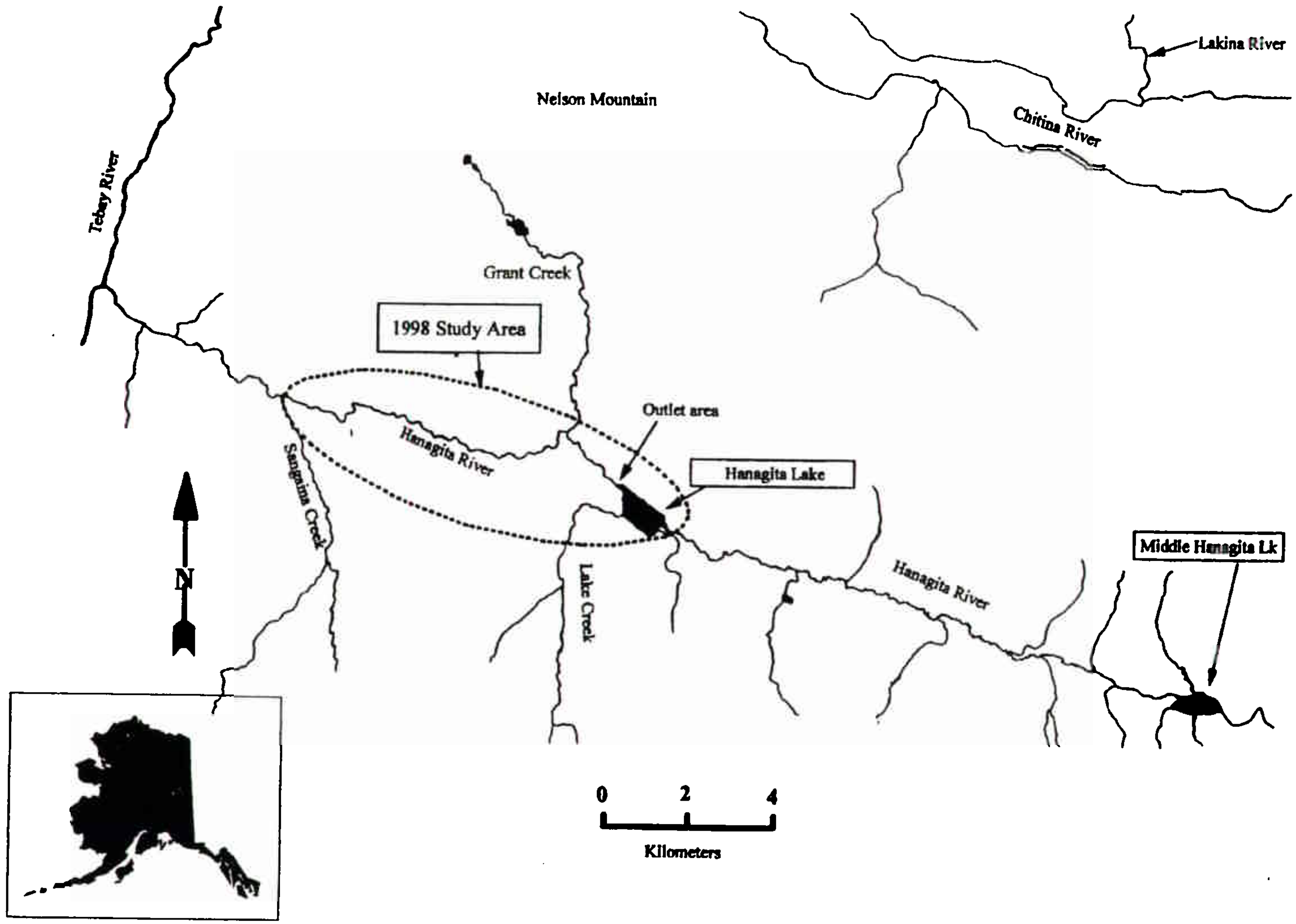

Figure 5.-Map of the Hanagita River study area.

Hanagita Lake, the river gradually descends from Upper and Middle Hanagita lakes through an open valley comprised of wet-muskeg tundra. Immediately upstream of Hanagita Lake the (upper) Hanagita River is comprised of a shallow, silty channel for approximately 2 mi. Above this point the stream habitat alternates between a low gradient meandering channel and steeper gradients with intermittent pool-riffle sequences.

Most of the drainage below Hanagita Lake is below tree line with predominately dense willow growth, scattered spruce, and sparse riparian stands of cottonwood trees. Upstream of Hanagita Lake, the vegetation type adjacent to the Hanagita River in the valley bottom is comprised of wet muskeg tundra and mixed stands of willow and spruce abutting adjacent mountain slopes.

Surveys, Timing, and Field Sampling

Field investigations of rainbow and steelhead trout in the Upper Copper River basin occurred during three time periods: the spring spawning, the summer feeding, and the fall-run steelhead migration periods. Spring spawning has been reported to occur within a three-week period beginning in late-May (Burger et al. 1983, Brink 1995, Stark 1999). The summer feeding period was defined as the time when Gulkana River resident rainbow trout feed on migrating juvenile salmon[4] and the eggs from the spawning chinook salmon in late-July. The fall-run steelhead migration period was defined as the time when a sufficient portion of the returning early-fall migrating steelhead trout had reached holding water in the Hanagita River as described in past records. This corresponded to September 10 to September 20.

In the Kaina Creek investigation, a crew of two conducted age and size sampling on rainbow and steelhead trout during the late May to early June spawning period. At the same time a crew of two persons conducted biological sampling on rainbow and steelhead trout in Hungry Hollow Creek, which is one of the known spawning areas in the Middle Fork Gulkana drainage. Immediately following these two field investigations, a crew of two members traveled to the other known Middle Fork spawning area below Dickey Lake to conduct biological sampling. After several days of sampling the crew traveled downstream and sampled throughout the Middle Fork and mainstem Gulkana River to investigate whether spawning trout or steelhead were present outside of the known spawning areas. In late July, a crew of two members sampled trout along the mainstem Gulkana between Paxson Lake and Sourdough. This time corresponded to the mid-summer feeding period. In mid-September, a crew of three attempted to conduct a mark-recapture stock assessment of rainbow and steelhead trout within a portion of the Hanagita River near Hanagita Lake.

Kaina Creek

A four-day field investigation included a survey of the Kaina Creek drainage and biological sampling of rainbow and steelhead trout was conducted in late May, 1998. Since no previous field investigations on rainbow or steelhead trout had been undertaken there, the late-May to early-June sampling time was determined from an earlier radiotelemetry study (Burger et al. 1983). Late May to early June corresponds to the estimated spawning times for the radio- tagged steelhead.

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4 This is reported as juvenile salmon instead of smolt, sockeye smolt, or juvenile chinook because these schooling salmon were not identified to species or growth phase or stage.

A crew of two traveled by fixed-wing aircraft on May 29 to a location approximately 1 mi below Upper Kaina Lake (Figure 4). A small inflatable canoe was used to carry camping and sampling gear from the starting location to the outlet of Kaina Lake (Figure 4). Weather conditions delayed the start of the project, reducing sampling to 21 mi in four days, rather than the planned 30 mi in seven days. Sampling gear included hook-and-line and an experimental sinking gillnet. Angling with hook-and-line gear allowed all habitats to be fished, and the use of gillnets was limited to slower and deeper water. The crew used a variety of artificial lures with lightweight spinning tackle (8 lb line strength). Hook and lure sizes were purposely kept small to minimize size selectivity for larger fish. Lures commonly included spinners (size #1 and #2; colored silver, blue, and orange), lightweight (1/32 to 1/16 ounce) plastic or feather single hook jigs, and weighted flies patterned after salmon eggs. One crew member walked and fished while the other crew member tended the canoe carrying the camping and other sampling gear. Once the crew reached the outlet area of Kaina Lake, both crew members participated in angling, and sampling gears were carried in backpacks.

The gillnet was 150 ft long by 6 ft tall and comprised of five mesh sizes of clear monofilament distributed in 30 ft panels. Mesh sizes were 0.5 in, 0.75 in, 1.0 in, 1.37 in, and 1.5 in. The gillnet was set in several locations of Kaina Creek upstream of Kaina Lake in deeper areas of slow moving water for soak times ranging between 1 and 10 h (overnight).

Rainbow trout and steelhead were sampled immediately following capture to minimize stress from handling. Each fish was contained in a deep-bag landing net during sampling to avoid exposure to air (Ferguson and Tufts 1992). Sampled pre-spawning trout were classified as rainbow trout or steelhead based on visual characteristics. Rainbow trout had a dense spotting pattern over all of the fish; had a medial rose- to red stripe, and the observed scale patterns showed no signs of extensive saltwater growth as seen in steelhead. Steelhead have far fewer spots which are not rounded and copper to reddish brown coloration below the lateral line which extends to the ventral surfaces. Additionally, we noted all sampled fish of this description had an abraded patch of scales and integument along the margin of the anal fin where sea lice had been attached, and extensive saltwater growth was later indicated by the observed scale pattern. Fish were measured to the nearest 1 mm FL, given a partial finclip, and tagged with an individually numbered Hallprint™ anchor tag (44,000 series) prior to release. A portion of the upper caudal fin was removed from each fish sampled in Kaina Creek. The removed fin tissue (~0.4 in^2 or 1 cm^2) was preserved in alcohol and stored in individual vials for future genetic analysis. A smear of at least five scales was collected from each rainbow or steelhead trout. Scales were removed by tweezers from an area approximately two scale rows above the lateral line, along a diagonal running from the posterior insertion of the dorsal fin towards the anterior insertion of the anal fin (Alvord 1954; Maher and Larkin 1955).

Gulkana River

On May 30, 1998, a crew of two backpacked into the Hungry Hollow Creek study area that was located downstream of Wait-a-Bit Lake (Figure 2). The crew hiked along Hungry Hollow Creek and used angling to capture rainbow and steelhead trout from spawning concentrations. The crew used weighted flies patterned after salmon or steelhead eggs to capture fish. Hooked fish were quickly brought into a large landing net downstream from other fish to avoid spooking uncaught fish that remained in the spawning aggregates. Fish were sampled in the water to avoid prolonged air exposure. Sampling procedures were similar to Kaina Creek except that fish were given a partial adipose finclip, in which the trailing lobe was clipped vertically similar to Stark (1999).

On June 3, 1998, a crew of three left the Denali Highway and traveled 19 mi by 6-wheel off road vehicles (ORV's) along the Swede Lake and Middle Fork trails to reach the spawning area below Dickey Lake. On that date, the lake was still ice covered. Like Hungry Hollow, the crew hiked along the river and captured fish by angling. Sampling procedures were similar to Hungry Hollow Creek except that fish were given a different finclip. The adipose fin was partially clipped in a horizontal direction following Stark (1999). After several days, a crew of two began traveling downstream by raft to sample along the remaining 21 mi of the Middle Fork and 43 mi of the Mainstem Gulkana to Sourdough. We attempted visual counts of current and vacant redds through the 3 mi stretch starting below the outlet of Dickey Lake. Angling was conducted throughout the trip in varied habitat to locate other spawning or feeding concentrations of rainbow or steelhead and to collect current age and size composition data on fish available to early-season anglers.

A second trip down the mainstem Gulkana River between Paxson Lake and Sourdough was conducted in late July. A crew of two traveled by raft and sampled rainbow trout in feeding areas along the Mainstem. Again, rainbow trout were captured by hook-and-line gears. This was the ideal gear because of the size and flow of the river through the canyon area and other feeding areas. Sampling methods were similar to the earlier sampling trips except that rainbow trout were given a partial lower caudal finclip. Additionally, all captured fish were examined for markings from earlier sampling to define patterns of movement and stock mixing from fish marked during the spring spawning period.

Hanagita River

On September 11, a crew of three traveled by floatplane to Hanagita Lake to conduct a mark-recapture stock assessment (Figure 5). We initially traveled along the river between the lake outlet and a location mid-way between the lake and Sangaina Creek to survey and determine reaches which could be sampled by angling or seine. The planned 6 mi sampling area was shortened after finding that the river changed to near-constant rapids at a point 1.5 mi below Hanagita Lake. The crew sampled fish for the mark-recapture study during the eight days at the field site. Because of the fall timing, we attempted to sample with multiple gears including nets, which if used during spring spawning may have interfered with spawning behaviors or egg deposition. The gear types included angling and seining. Angling with hook-and-line gear allowed all habitats to be fished. The crew used a variety of artificial lures with medium weight spinning tackle (8-12 lb line strength). Hook and lure sizes were purposely kept small to minimize size selectivity for larger fish. Lures commonly included spinners (size #1 and #2; colored silver, blue, and orange), single hook plastic or feather jigs (1/16 to 1/8 ounce), and weighted flies patterned after salmon eggs. The seine selected for use was a clear monofilament sinking gillnet with a 1 in stretched mesh, 100 ft in length, and 8 ft in depth. It was fished in several areas where fish had been non-responsive to angling gear.

No fish were captured after several days of sampling in the 1.5 mi study area. The investigation focused on age and size composition sampling and locating concentrations of holding fish within and outside the planned study area. Information given to us by a sport angling guide indicated that steelhead have been captured by guided anglers above Hanagita Lake in the Hanagita River. This area was added to the existing study area, but sampled only once because of its distance and difficulty to reach by foot.

All fish were sampled in a similar manner to earlier 1998 field studies (handling, measuring, tagging, and fin tissue collection) and given a partial upper caudal finclip.

DATA COLLECTION AND ANALYSIS

Data collected were electronically stored and the data file listing can be found in Appendix A. Following the field project, scale samples were sorted under a dissection microscope and three scales that appeared to be complete with no regeneration were cleaned and mounted on gumcards. Gum cards were then used to make triacetate impressions using a scale press (30 s at 137,895 kPa, at a temperature of 97°C). Ages were determined by counts of annuli from impressions of scales magnified to 40X with the aid of a microfiche reader. Scale analysis and age determination of rainbow trout incorporated aging criteria developed by Beamish and McFarlane (1987) and Dunaway (1993). Estimated age was determined by counting regions of the scales where circuli were broken or compacted. Aging of anadromous steelhead was supplemented with methods and criteria from Jones (*Unpublished*) on determining and reporting ages of fall immigrant steelhead. For steelhead, scales without a completed spawning check were defined as initial or first time spawners. Fish with previous spawning checks were defined as repeat spawners. Spawning checks appeared on scales of repeat spawners as interruptions of the normal circuli growth as seen by reabsorbance or erosion at the scale margin during freshwater residence and spawning (Jones *Unpublished*). Completed spawning checks were indicated by resumption of circuli growth.

Age designation for anadromous steelhead is a modification from the European method to incorporate life history information on repeat spawning. For example, an assigned age of 3.2s is an age-5 spawner which: 1) spent 3 winters (years) in fresh water prior to smolt emigration, and 2) returned to spawn in fresh water in October during its second year at sea, so it spent 2 winters (years) at sea. The letter "s" represents a freshwater immigration (spawning event) and numbers represent years between events.

SAMPLE COMPOSITION ESTIMATES

Age and length data from rainbow and steelhead trout were used to estimate composition when feasible. The 1998 field studies did not incorporate a mark-recapture experiment that would allow the examination and adjustment for sampling biases. Although the composition estimates may not be bias-free representations of all length and age classes of the population, they may be suitable for describing the catchable population, and to provide anglers with information. Composition data from Kaina Creek, the Gulkana River studies, and Hanagita River were analyzed within these constraints.

Proportions of fish by age captured during a single sampling event were calculated as:

$$\hat{p}_k = \frac{y_k}{n} \tag{1}$$

where:

$\hat{p}_k$ = the proportion of rainbow or steelhead trout (hereafter referred to as "trout")that were age *k*;
y_k = the number of trout sampled that were age *k*; and,
n = the total number of trout sampled.

The variance of this proportion was estimated as:

$$\hat{V}[\hat{p}_k] = \frac{\hat{p}_k(1-\hat{p}_k)}{n-1}. \quad (2)$$

Length composition was estimated in a similar manner, replacing age class with 25 mm FL incremental length classes.

Hypothesis Testing on Size Compositions

One objective of the multiple sampling trips on the Gulkana River was to provide information to compare size compositions between sampling times (during the Spring spawning and Summer feeding periods). To help describe the sizes of trout available to anglers between Paxson and Sourdough, sizes of fish at different times of the year were compared. The hypothesis that was tested is:

$\mathbf{H_0}$ = the difference in proportion of large (≥ 480 mm FL) rainbow trout in the Mainstem Gulkana River between the early June and late-July sampling periods is zero; and,

$\mathbf{H_a}$ = the difference between the proportions of large rainbow trout at the two sampling times is greater than or equal to 20%.

The proportions of large rainbow trout (≥ 480 mm FL) captured during the early-June and late-July sampling periods were tested with a 1-Tailed Z-Test (Zar 1984).

One use for the results of size comparisons was to help determine whether existing regulations adequately protect spawning stocks of rainbow and steelhead trout within the Gulkana River. For instance, if larger trout (likely spawners) are present in the mainstem areas only during the summer feeding period (late-July sampling period) then the current combination of regulations may adequately protect the majority of spawners from disturbance during the spawning period. If large trout are present at both times, then mainstem spawning areas could be inferred. This result may lead managers to increase protection of spawners in the mainstem at times of spawning.

Another use for size comparisons was to examine the fishery's ability to offer catchable numbers of trout greater than 20 in[5] (≥ 480 mm FL) to anglers traveling the mainstem Gulkana at different times of the open water season. The same information will be used in the development of future stock level monitoring of rainbow and steelhead.

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[5] The 1986-BOF approved Cook Inlet and Copper River Basin Rainbow/Steelhead Trout Management Policy identified the presence of rainbow trout greater than 20 in total length (≥480 mm FL) as one of the criteria for establishing special management areas for Catch-and-Release, Trophy, or High Yield management.

Length data from resident rainbow trout sampled before 1998 in the Gulkana River were examined in the context of a hypothesis test to describe changes in the sizes of fish available to anglers following catch-and-release regulations and gear restrictions. Kolmogorov-Smirnov two-sample tests (KS tests) were used to compare sampled lengths of fish captured in 1998 and earlier years by hook-and-line. Results of these examinations form a basis for monitoring shifts in size composition that may have resulted from the no-harvest regulation in the Gulkana River.

RESULTS

GULKANA RIVER

Tributaries and portions of the Gulkana River were visited and sampled in 1998 during the spring spawning period and later during the summer feeding period.

Hungry Hollow Creek

On May 30, a crew of two began sampling Hungry Hollow Creek, a tributary creek to the Middle Fork Gulkana River. The crew sampled from an area approximately 1 mi downstream of Wait-a-Bit Lake and captured 17 resident rainbow trout and seven steelhead by angling. Water levels were low and visibility was reduced by a light tannic stain in the water. Water temperatures ranged between 4° and 5° C. The crew sampled downstream 2 mi to a location 8 mi above the confluence with the Middle Fork Gulkana River. The sampling was completed at Hungry Hollow on June 1. Resident rainbow trout ranged from 277 to 562 mm FL, and steelhead ranged between 560 and 744 mm FL (Table 2). Ages of sampled rainbow trout ranged from 4 to 8, and ages of steelhead were 3.2 and 3.2s1. Small sample sizes precluded meaningful composition estimates in terms of length and age categories for Hungry Hollow Creek alone. However, when these spring spawning fish were pooled with those spawning fish collected near Dickey Lake on the Middle Fork, the sample was large enough to compare with samples taken from the summer feeding period on the mainstem Gulkana. The purpose for comparing spring spawning fish with summer feeding fish is to illustrate the differences in lengths and ages available to the angler at different times (spring and summer).

Middle Fork Gulkana

On June 3, a crew of three began sampling rainbow trout and steelhead in the known spawning area that extends 3 mi below Dickey Lake. Water conditions were low and clear with extensive aufeis (from winter upwelling and overflow conditions) bordering the river. This ice extended downstream approximately 2 mi through most of the spawning area and no spawning activity was found upstream of this point. Spot measurements of water temperatures ranged between 4° and 7° C. On June 5, we counted approximately 150 recently vacated redds, and observed several large fish passively drifting downstream. The large number of recently vacated redds indicated our sampling effort downstream of Dickey Lake was late relative to the peak in spawning activity. At the same time, one group of four fish were actively spawning near the lower end of the spawning reach, 2.5 mi downstream of Dickey Lake. We concluded that the 1998 spawning was near complete based on these observations and from past patterns of spawning activity observed by Stark (1999) in the Dickey Lake spawning area. We sampled and tagged seven resident rainbow trout and two steelhead by angling in this area.

Table 2.-Sample sizes, estimated proportions, and standard errors by age class and 25 mm FL incremental size groupings for rainbow trout and steelhead (≥150 mm FL) captured from Hungry Hollow Creek, May 30 through June 1, 1998.

Age[c]	Count	$\hat{p}$[a]	Se[b]
4	3	0.14	0.08
5	2	0.09	0.07
6	4	0.19	0.09
7	4	0.19	0.09
8	1	0.05	0.05
9	0	0.00	0.00
10	0	0.00	0.00
3.2[c]	6	0.28	0.10
3.2s[c]	1	0.05	0.05
Totals	21	1	---

Length	Count	$\hat{p}$[a]	SE[b]
300	3	0.12	0.07
325	0	0.00	0.00
350	1	0.04	0.04
375	0	0.00	0.00
400	1	0.04	0.04
425	2	0.08	0.06
450	3	0.12	0.07
475	3	0.12	0.07
500	0	0.00	0.00
525	2	0.08	0.06
550	0	0.00	0.00
575	2	0.08	0.06
600	0	0.00	0.00
625	0	0.00	0.00
650	1	0.04	0.04
675	0	0.00	0.00
700	2	0.08	0.06
725	2	0.08	0.06
750	2	0.08	0.06
Total	24	1.00	----

[a] $\hat{p}$ = proportion of rainbow trout in the sample.

[b] SE = standard error of the proportional contribution.

[c] These age designations used for anadromous steelhead are a modification from the commonly used European designation to incorporate life history information on repeat spawning. For example: a steelhead designated as 3.2 would be interpreted as 3 freshwater winters, followed by 2 saltwater winters. A fish designated as 3.2s or 3.2s1 would indicate a steelhead that is, or will be a repeat spawner .

Lengths of the resident rainbow trout ranged between 433 and 680 mm FL, and lengths of the two steelhead were 680 and 765 mm FL. Determined ages of rainbow trout ranged from 5 to 8 years, and the two steelhead ages were 3.2 (three freshwater annuli: two salt water annuli) and either R.1S1S or R.1SS (where R and S represent regenerated regions of the scale and spawning events). Information on sampled fish was:

Tag number	Date	Type/Form	Length	Sex	Age	Location/ notes:
44151	6/4/98	steelhead	765 mm	M	3.2	~2.5 mi below Dickey Lk; active redd
44152	6/4/98	steelhead	680 mm	F	R.1S1S	~2.5 mi below Dickey Lk; active redd
44153	6/4/98	rainbow	610 mm	M	7	~2.5 mi below Dickey Lk; active redd
44156	6/4/98	rainbow	680 mm	M	6	~2.5 mi below Dickey Lk; active redd
44157	6/4/98	rainbow	510 mm	F	7	~2.5 mi below Dickey Lk; active redd
44158	6/5/98	rainbow	530 mm	M	8	~2 mi below Dickey Lk
44159	6/5/98	rainbow	590 mm	M	5	~2.5 mi below Dickey Lk; active redd
44160	6/5/98	rainbow	433 mm	U	7	~2.5 mi below Dickey Lk; active redd
44161	6/5/98	rainbow	440 mm	M	6	~2.5 mi below Dickey Lk; active redd

Again, small sample sizes precluded meaningful composition estimates in terms of length and age categories, but allowed for cumulative distributions by size to be subjectively compared with trout sampled at differing locations and times in the Gulkana.

Stream depths near vacant and active redds ranged between 6 and 18 in, with greater depths within the redd pits. The majority of the fish spawned on medium to coarse alluvial gravel located in the thallweg of singular and braided channels, which were bounded by shelves of aufeis accumulation. Based on the distribution of redds throughout the area, a minority of fish had spawned (or were spawning) in the lower portion of the spawning area, which had more pool riffle sequences, and little or no adjacent aufeis accumulation.

After leaving the Upper Middle Fork spawning areas, we rafted downstream and sampled in the remaining 21 mi of the Middle Fork and 43 mi of the mainstem Gulkana River ending at Sourdough. No additional fish were captured in the Middle Fork, but one fish was observed approximately 2 mi above Hungry Hollow Creek.

Habitat along the Middle Fork and mainstem Gulkana River was thoroughly described by Stark (1999) and will not be described in such detail for this report. The Middle Fork channel habitat is, however, varied from high gradient (near 100 ft/mi) to very low gradient (< 10 ft/mi). In the upper reaches the flow was rapid with large cobble and small boulders. The flow quickly moderated over the fork's remaining course to include low gradients and gravel, sand, and silt substrates. Portions of the Middle Fork showed rapid change in the channel by erosion at oxbows, while other areas appeared exceptionally stable with well vegetated banks extending to the river's edge, with no sloughing of bank material and associated tree cover. The Middle Fork's channel changed to faster flows with bedrock, scattered boulders, and gravel substrates within 1 mi of the confluence with the mainstem Gulkana.

Mainstem Gulkana (Early June)

While traveling the mainstem Gulkana River between the confluence with the Middle Fork and Sourdough, we captured seven resident rainbow and no steelhead. Of these, five fish were captured by angling in the area known as the Canyon Rapids and the remaining two were caught in the rapids extending downstream 8.5 mi. Sizes of the resident rainbow trout ranged from 200 to 460 mm FL and determined ages of rainbow trout ranged from 2 to 8 years. Sex or the condition of maturity could not be determined from any of these fish. Information on sampled fish was:

Tag number	Date	Type/Form	Length	Sex	Age	Location:
44163	6/9/98	Rainbow	305 mm	U	3	Canyon Rapids at falls
44164	6/9/98	Rainbow	220 mm	U	2	Canyon Rapids at falls
44165	6/9/98	Rainbow	340 mm	U	4	Canyon Rapids at falls
44166	6/9/98	Rainbow	200 mm	U	3	Canyon Rapids at falls
44167	6/10/98	Rainbow	205 mm	U	3	Canyon Rapids at falls
44169	6/10/98	Rainbow	400 mm	U	NA	0.5 mi below falls
44173	6/10/98	Rainbow	460 mm	U	8	2 mi below falls

Upstream of the canyon area the river channel and associated habitat varied significantly. Starting at the confluence with the Middle Fork, the river was primarily a single channel with pool-riffle sequences with gravel and small to large cobble. The river then changed to a section of flatwater with a deep and slow meandering channel of sand and silt substrates. Immediately upstream of the canyon rapids the river had a wide and stable channel with shallow rocky riffles and long runs. The canyon area consisted of a quarter-mile reach of heavy rapids (class III and IV whitewater) formed by a sudden change in stream gradient and change to large boulders and bedrock ledges. It is easily located by BLM signs identifying an adjacent portage trail. This geologic and hydrologic feature has created numerous locations for trout to feed upon schools of juvenile salmon passing through the heavy rapids. In early-June, we observed numerous Arctic grayling feeding on juvenile salmon in dense schools as they passed through the canyon area. Arctic terns and Bonapart's gulls followed and fed on the schooled salmon in the same location throughout the day and much of the night. To best simulate the juvenile salmon we used lures such as Rapala™ minnows, flies patterned after salmon smolt, and general attractor-type lures such as small plastic jigs and small spinners. Immediately downstream of the canyon area the river moderates but remains rapid (class II and III whitewater). After 8.5 mi of rapids the river's gradient moderates again and the habitat includes a greater quantity of pool/riffle sequences with gravel and small cobble substrate. Above the confluence with the West Fork Gulkana River, the channel splits into several well separated channels, with near uniform depth and larger cobble substrates. Below the West Fork confluence, the channel remained singular, with deeper pools, bordered by sloughing gravel banks and gravel bars for the remaining 8 mi to Sourdough.

Mainstem Gulkana (late- July)

On July 24, resident rainbow trout sampling began along the mainstem Gulkana River between Paxson Lake and Sourdough. This time corresponded to the summer feeding period. This section of river is commonly referred to as the "float reach" and is primarily used by floaters in rafts or canoes. Our crew of two and a second crew of six that were assessing size and age composition of Arctic grayling along the same section, first traveled to the outlet of Paxson Lake in rafts. We began sampling resident rainbow trout between Paxson Lake and the confluence with the Middle Fork. In this area, trout were feeding on eggs from spawning chinook salmon and on juvenile salmon traveling through the small rapids and areas of high turbulence. Between the Middle Fork confluence and the Canyon Rapids, we captured trout in areas where spawning chinook salmon were present, while Arctic grayling were located throughout the reach. At the Canyon Rapids trout were feeding on juvenile salmon. No salmon were observed spawning in this stretch of river. After the rapids dissipated approximately 8.5 mi downstream, trout were again located with spawning chinook salmon. As in the earlier trip during June, we used lures or flies that represented available food, i.e. smolt or egg imitation lures or flies, and attractor lures in a wide variety of sizes to minimize selective biases. The second crew used small plastic jigs which were 1/32 to 1/16 ounce sizes and in some instances used egg imitations.

In the six days on the river we caught 45 trout and the second crew caught 10 in the float reach of the Mainstem Gulkana. Two trout previously tagged in the Upper Middle Fork during the spring spawning period were recaptured. One recaptured fish (tag number 44159) was originally sampled, tagged and released on June 5 below Dickey Lake. The other recaptured fish was missing its tag (cut off) but retained the vertically-clipped adipose fin identifying it from the Hungry Hollow sample. These tag recoveries verified the use of the Middle Fork spawning areas by fish that use the Mainstem Gulkana in July, and indicated seasonal spawning or post-spawning migration distances to 70 mi.

Lengths of the resident rainbow trout ranged from 210 to 630 mm FL and ages ranged from 2 to 9 years (Table 3). The median age was 4 and median size was 402 mm FL (16.5 in). The average age was 4.7 years, and mean length was 417mm FL (17 in). Rainbow trout at or in excess of 20 in ($\geq$ 480 mm FL) comprised 25% of the sample. Many fish captured in the area of the Canyon Rapids had mouth damage, which was probably a result from past hooking.

Hypothesis Testing and Size Comparisons

Within the early-June sample along the Mainstem Gulkana River, none of the seven fish were considered to be large trout (defined as $\geq$ 480 mm FL or 20 in TL). In the late-July sample, 25% or 14 of the 55 sampled fish were large trout. A 1-Tailed Z-test comparison of these proportions did not indicate a statistically significant difference ($Z= 1.52$, $p= 0.06$).

A comparison was made between the 1998 late-July samples of angled rainbow trout from the mainstem Gulkana River and historical data on lengths of angled trout captured during past ADF&G studies along the same areas of the Gulkana River. Lengths of trout angled during these summer Arctic grayling sampling trips that were conducted between 1987 and 1992 (Figure 6) were pooled. This sample of 137 lengths corresponded to trout sampled prior to- and shortly after changes to the 1991 no-harvest regulation along the Gulkana. The Kolmogorov-Smirnov two-sample test indicated a shift in the size composition of samples towards larger fish following changes in trout management along the Gulkana River (Figure 7; $D= 0.31$, $P= 0.0009$).

Cumulative length compositions from Spring spawning samples (Middle Fork areas, and mainstem Gulkana) and summer feeding samples were also plotted (Figure 8). The plot indicates a generalized segregation by sizes during the spawning period, although small sample sizes from the mainstem in the early-June sample ($n= 7$) lacked power for statistical comparisons.

KAINA CREEK

Between May 29 and June 2, a stream survey was conducted along Kaina Creek to locate and sample rainbow and steelhead trout. No fish were captured by angling or gillnetting in the two days of surveying and sampling between a location 1 mi below Upper Kaina Lake and Kaina Lake. At the starting location (downstream of Upper Kaina Lake) and downstream approximately 1 mi, the creek channel was 35 to 50 ft wide, 12 to 24 in deep, with nearly continuous swift water and rapids. Beyond this point, the stream gradient lessened, with more pool riffle sequences present, and several instances where the channel split (no more than two channels). In this reach substrates shifted to smaller sizes of cobble and coarse gravel. Water conditions were generally clear and stream temperatures ranged from 3.5° to 6° C by evening. Peak flows occurred in the late afternoon, resulting from snowmelt in the upper valley and adjacent slopes. No fish activity was observed in this section by angling along the creek or in the several small side channel tributaries which entered from beaver ponds or flowages.

During the second day of travel, the creek channel and adjacent habitat went through a transition to include proportionally more pool habitat, and the first sightings of sockeye salmon skeletons from the previous year occurred here. The creek changed to include minor stream braiding and increased amounts of woody debris and resulting channel blockages. The adjacent riparian and valley habitat also changed briefly to stands of spruce forest and then changed to open tundra with low willow growth and scattered stands of spruce. On this day increased turbidity, tannic staining, and some floating debris were observed in the afternoon hours, arising from snowmelt, adjacent beaver flowages, and small areas of overland flow. Water temperatures ranged between 3° and 6.5° C. Although water conditions were generally suitable for angling and netting (in several locations), no fish were seen or captured.

Immediately after starting out on the third day, the stream channel changed to a lower gradient (estimated average gradient: 10 ft/mi), with slow meandering flows and sand and silt substrates until reaching Kaina Lake. In this section water conditions were poorer, with more turbidity and some minor flooding over the creek banks in low lying areas. In this section, gillnets and angling failed to capture any fish. After reaching Kaina Lake, we traveled 1.5 mi to the outlet. Ice pans were present along some of the windward shorelines. Three lake trout (400 to 600 mm FL) were captured near the inlet to the lake during 30 min of angling. At Kaina Lake's outlet, Kaina Creek was 110 ft wide and substrates varied with location. Near the lake, large cobbles were covered by periphyton, and heavy growths of filamentous algae, and mosses. One small Arctic grayling was captured in this area, but no other pre- or spawning adult Arctic grayling were captured. Downstream 100 yd, the creek channel was composed of loose, washed gravel and small cobbles and was bounded to the east by a low-lying ridge. At the base of this ridge we observed and captured spawning rainbow and steelhead trout on active redds. We hooked and landed one steelhead and four resident rainbow trout, and lost one other large female steelhead. Information of sampled fish was:

Tag number	Date	Type/Form	Length	Age	Location:
44200	5/31/98	rainbow	440 mm	8	Kaina Lake outlet; active redd
44201	6/1/98	rainbow	595 mm	6	Kaina Lake outlet; active redd
44202	6/1/98	rainbow	420 mm	7	Kaina Lake outlet; active redd
44203	6/1/98	steelhead	705 mm	3.2	Kaina Lake outlet; active redd
44204	6/1/98	rainbow	425 mm	6	1.5 mi below Kaina Lk

Table 3.-Sample sizes, estimated proportions, and standard errors by age class and 25 mm FL incremental size groupings for rainbow trout (≥150 mm FL) captured from the Mainstem Gulkana River, July 24 through July 29, 1998.

Age	Count	$\hat{p}$[a]	SE[b]
2	4	0.07	0.04
3	16	0.30	0.06
4	8	0.15	0.05
5	4	0.07	0.04
6	10	0.18	0.05
7	7	0.13	0.05
8	4	0.07	0.04
9	1	0.02	0.02
10	0	0.00	0.00
Totals	54	1	---

Length	Count	$\hat{p}$[a]	SE[b]
225	2	0.04	0.02
250	2	0.04	0.02
275	5	0.09	0.04
300	3	0.05	0.03
325	1	0.02	0.02
350	1	0.02	0.02
375	5	0.09	0.04
400	7	0.13	0.04
425	3	0.05	0.03
450	4	0.07	0.03
475	5	0.09	0.04
500	3	0.05	0.03
525	3	0.05	0.03
550	2	0.04	0.02
575	4	0.07	0.03
600	4	0.07	0.03
625	0	0.00	0.00
650	1	0.02	0.02
Total	55	1.00	----

[a] $\hat{p}$ = proportion of rainbow trout in sample.

[b] SE = standard error of the proportional contribution.

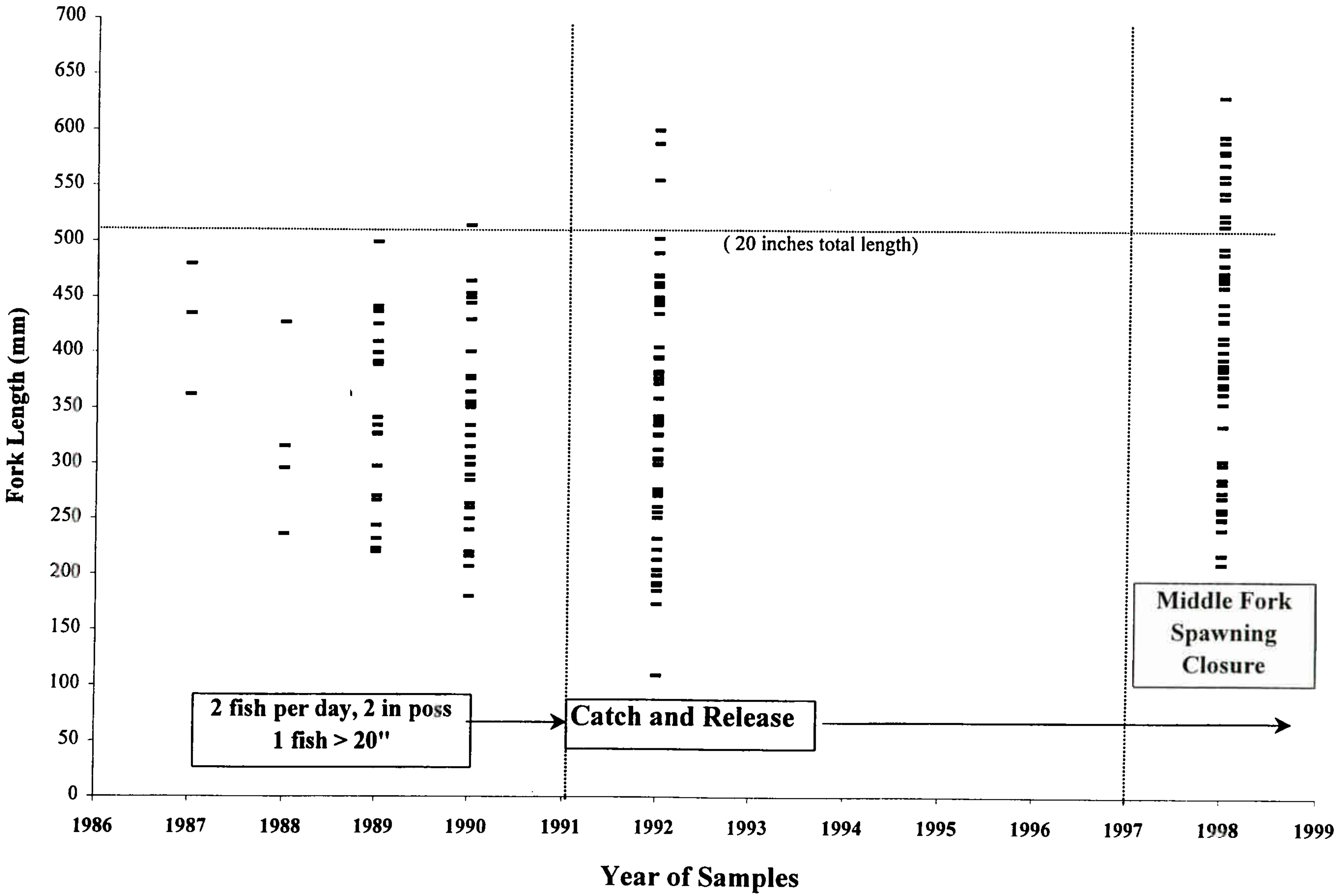

Figure 6.-Lengths of resident rainbow trout captured by angling between Paxson Lake and Sourdough during a late-June to early-September period on the mainstem Gulkana River, from 1998 and from archived (1987-1990, 1992) data.

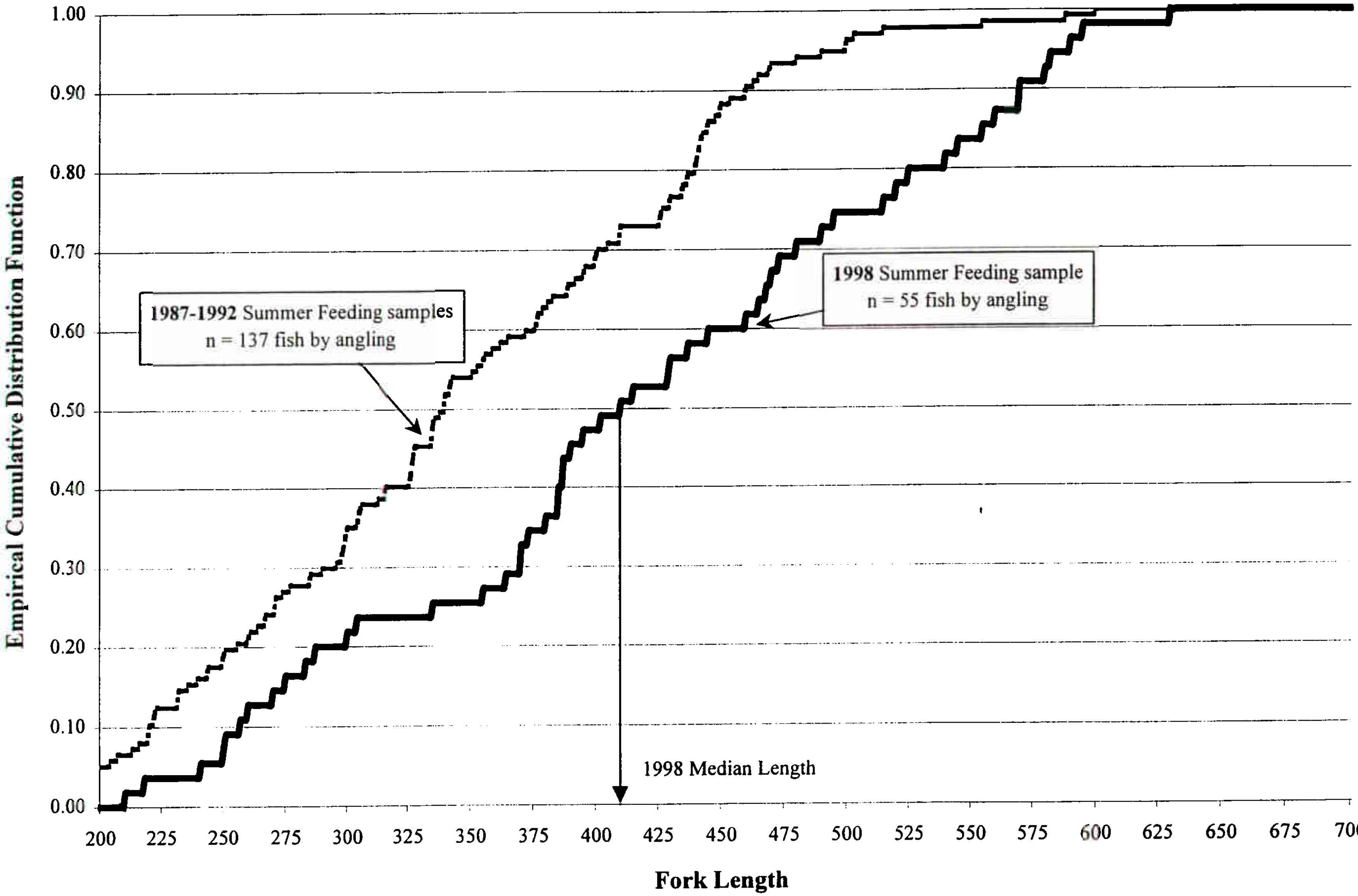

Figure 7.-Empirical cumulative distribution functions (CDF) of lengths of resident rainbow trout sampled prior to and following changes to a no-harvest regulation on the Gulkana River.

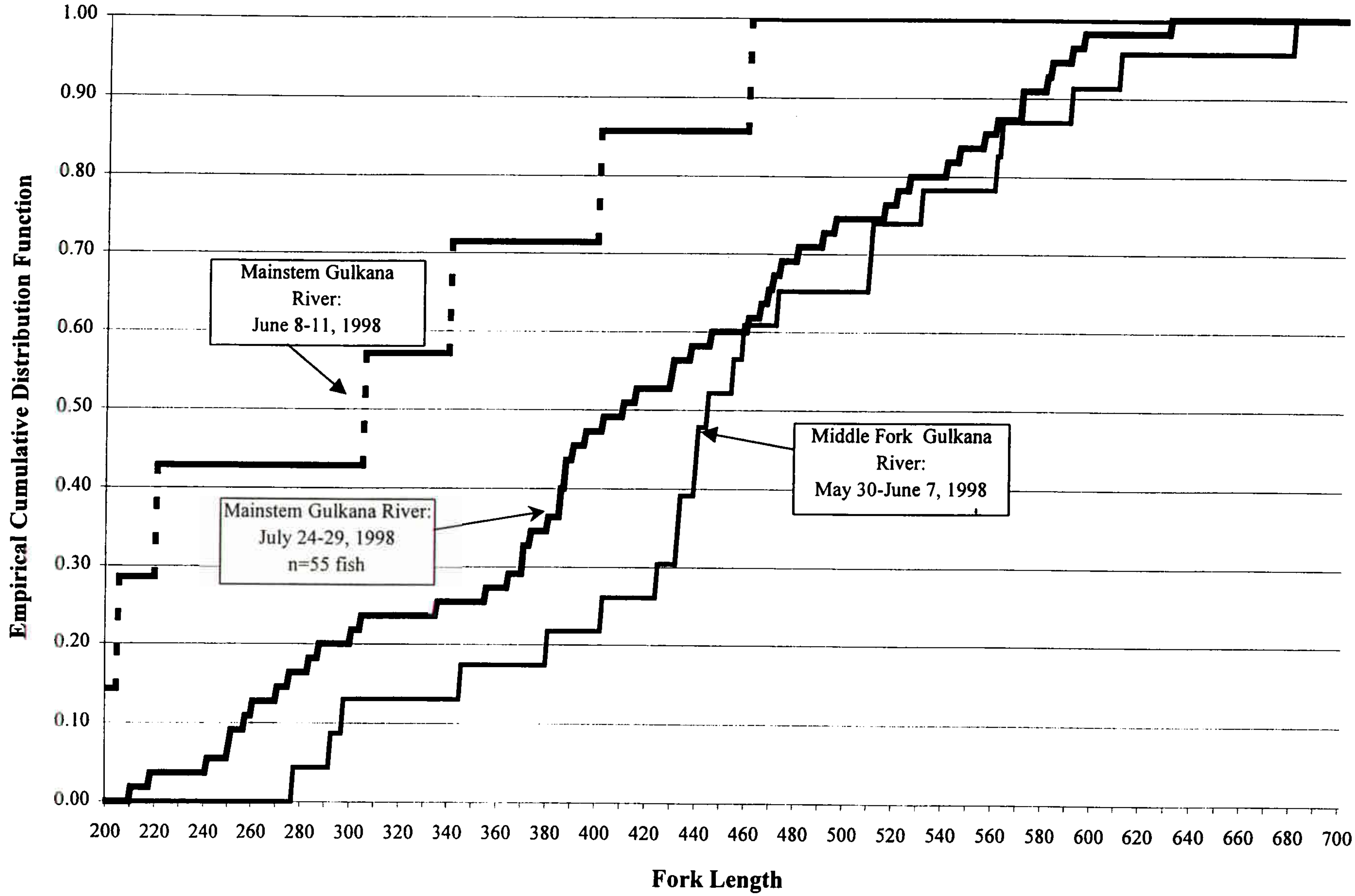

Figure 8.-Cumulative length distribution functions of resident rainbow trout sampled at differing times and from differing areas along the Gulkana River during 1998.

A total of eight redds were observed with a maximum of five trout (rainbow and steelhead, combined) present at any one time in, or near the redds. Water depths in this portion of the outlet were between 1 and 5 ft. Depths within the observed redd pits ranged from 2 to 4 ft. Within the 4 mi survey below Kaina Lake, the creek channel widths ranged from 50-75 ft with swifter stream velocities. We captured a single rainbow trout in an area 1.5 mi downstream of the lake outlet that contained numerous redd pits created by previous year spawning chinook salmon. Our survey and sampling ended 2.5 km mi beyond this location on June 1, where the gradient and water velocity again increased significantly as Kaina Creek entered a small incised canyon (Figure 4).

HANAGITA RIVER

On September 11, a crew of three flew to Hanagita Lake to begin sampling steelhead and rainbow trout. Following several days of sampling downstream from the outlet of Hanagita Lake it became apparent that a mark-recapture estimate of abundance was not possible in the designated 6 mi study area as originally planned. This was because the study area was constrained by the habitat available for steelhead and rainbow that could be sampled. At a location 1.5 mi downstream of the lake, the river gradient dramatically increased, resulting in nearly continuous heavy whitewater. This reach could not be reasonably accessed or sampled using any of the available gears (hook and line, seining, gillnet). As a result, the three-person crew sampled a 1.5 mi section of the Hanagita River. Only 10 steelhead were sampled (9 marked), which was too few to provide a sufficient sample size for mark-recapture estimates and composition estimates. Furthermore, even if sufficient numbers would have been captured there were no indications that geographic closure existed within the study area. No steelhead were observed holding or concentrating in, or immediately below the lake outlet area as suggested by earlier accounts, and no fish were recaptured. We believed that marked and unmarked fish passed upstream and out of the study area. This was confirmed when we captured two adult steelhead well above Hanagita Lake, upstream of the documented range for this anadromous stock (ADF&G 1998).

The 10 sampled steelhead were captured by angling using spinning gear with spinners, weighted jigs, or flies. Captured fish appeared and acted to be in good physical condition, with little or no spawning coloration present. We found significant mouth damage on one fish and net marking on four of the sampled steelhead. Other species captured or observed included Arctic grayling, lake trout, resident Dolly Varden, and round whitefish *Prosopium cylindraceum*. Limited seining and blocknetting with 1 in monofilament-mesh gillnets was ineffective, as was gillnetting in Hanagita Lake. Several Arctic grayling were caught in the river by seining and two round whitefish were caught from three 20 min gillnet soaks at 10 to 20 ft depths near the outlet end of the lake. Unlike Kaina Creek, we found no evidence of resident rainbow trout or indications of salmon use in 1998.

Sizes of the steelhead ranged up to 860 mm FL (34 in) and 5.5 kg (12 lbs) with the most common determined ages being 3.2 (3 freshwater years: 2 saltwater years). Information on the sampled fish was:

Tag number	Date	Type/Form	Length	Sex	Age	Location/ notes:
No tag	9/12/98	steelhead	745 mm	M	3.2	0.25 mi below lake
44085	9/13/98	steelhead	555 mm	U	3.1	0.5 mi below lake
44086	9/13/98	steelhead	625 mm	F	3.1	0.5 mi below lake
44088	9/13/98	steelhead	785 mm	F	3.2s1	1.5 mi below lake
44089	9/13/98	steelhead	860 mm	M	3.2	1.5 mi below lake
44090	9/13/98	steelhead	680 mm	F	3.2	0.5 mi below lake
44091	9/14/98	steelhead	550 mm	U	3.1	0.75 mi below lake
44092	9/15/98	steelhead	770 mm	M	3.2	1.5 mi below lake
44093	9/16/98	steelhead	540 mm	U	3.2	2.5 mi above lake
44094	9/16/98	steelhead	615 mm	F	3.2	2.25 mi above lake

The Hanagita River drainage in the vicinity of Hanagita Lake included varied habitat. Below the lake, the Hanagita River channel ranged from 30 to 50 ft wide, with depths varying with stream features (pools, runs, or riffles) and up to approximately 8 ft deep in one location. Between Hanagita Lake and the lower study area boundary, the river alternated between pool, riffle and run sequences with direction changes of the river's course. Average stream gradient was approximately 35 ft/per mi in the 1.5 mi stretch. Substrates varied with stream features and ranged between fine gravel and sand to coarse cobbles and small boulders. Water conditions during the study period were clear and stream temperatures ranged from 3.5° to 6° C by evening. At the study area boundary located 1.5 mi downstream, the channel became notably different. There was an immediate loss of pool and slower areas that offer holding water, and the stream gradient and current velocity increased significantly. Although we did not continue ground surveys further downstream to Sangaina Creek, we observed the river by hiking adjacent ridges and later by aerial survey. The intensity of whitewater increased with an estimated stream gradient average of 115 ft/mi before reaching the confluence with the Tebay River 10.7 mi below Hanagita Lake (estimated range: 55 to 169 ft/mi). Below the confluence, the Tebay River runs 10 mi as heavy whitewater with an estimated average stream gradient of 124 ft/mi (estimated range: 47 to 375 ft/mi) before reaching the Chitina River. Hanagita Lake, reported to be 30 ft deep, appeared to be relatively productive with emergent vegetation and an extensive littoral zone covering approximately 2/3 of the lake. The inlet stream, or the upper portion of the Hangita River is approximately 20 ft wide, and approximately one foot deep, with sand and silt substrate nearest the lake. Further upstream, the river becomes generally deeper and the channel varies between slow and silty portions and fast water portions with some pool riffle sequences. Based on an aerial survey of the valley this pattern continues to Middle Hanagita Lake for an additional 7 mi. Upstream of Middle Hanagita Lakes, the river was blocked by numerous beaver dams.

DISCUSSION

In 1998, rainbow trout research was conducted in three distinct areas of the Copper River drainage where previous assessment was limited or outdated.

GULKANA RIVER

In the past eight years (1991-1998) management actions were designed to reduce sport harvests of Gulkana River rainbow trout and steelhead to conserve stocks and allow undisturbed spawning. Although no comprehensive stock assessments have been conducted on Gulkana River trout, the results of this study indicated that greater numbers of large trout may be present in the commonly floated reach of the river between Paxson Lake and Sourdough. Estimates from statewide catch, harvest and participation surveys have indicated increased catches of rainbow following the change to a no-harvest regulation (Figure 3: Mills 1993, 1994, Howe et al. 1995, 1996, 1997, 1998). However, catches of steelhead do not reflect the same trend, probably because anglers are now restricted from angling in known spawning areas in late-May and early-June.

Our spring sampling within the Middle Fork Gulkana River headwaters and mainstem indicated that spawning trout and steelhead were aggregated in two areas of the Middle Fork drainage for a brief period, supporting recent work conducted by Stark (1999). No conclusions could be drawn on the relative abundance of rainbow or steelhead based on direct observations because of the late timing of sampling conducted at the Dickey Lake spawning area. The sampling conducted at Hungry Hollow Creek was thought to have been conducted at, or near the peak of spawning. Stream conditions at Hungry Hollow Creek were not as conducive for visual counts as in the Dickey Lake spawning area.

We found that during early-June, few trout were available for anglers to catch along the Mainstem Gulkana, and those sampled were often smaller fish. The small sample size of fish did not include large trout (fish 20 in or larger) which were present in the more numerous July sample. Moreover, two larger trout tagged outside of the mainstem Gulkana River, at Dickey Lake and Hungry Hollow Creek spawning locations, moved downstream and were recovered in the mainstem in July. Both fish were captured in the canyon area, where we observed trout ambush and feed on emigrating juvenile salmon. Angling was very productive in this area during the July trip, and also in areas used by spawning chinook salmon. Smaller trout were captured in salmon spawning areas located upstream and downstream of the canyon rapids. Based on sampling conducted in 1998, the mainstem Gulkana River upstream of Sourdough hosts a fishable population of resident rainbow trout during the summer months that includes large trout. We estimated that approximately 25% of the 55 trout sampled during July were in excess of 20 in.

This study suggests that the resident rainbow trout population has responded favorably to changes in management and can offer anglers reasonable opportunities to catch and release large rainbow trout in the Interior of Alaska. On the other hand, the opportunities for anglers to fish for and catch steelhead from the Gulkana River are limited by their seasonal presence and regulation. Anglers may catch and release steelhead while salmon fishing but directed fishing in the known spawning grounds is closed. Unlike the resident rainbow trout, steelhead are subject to additional hazards in their migrations between fresh and saltwater. A variety of fisheries (commercial, subsistence, and personal use) conducted in the Copper River drainage incidentally harvest adult steelhead travelling to or from the Gulkana River. Following this season of tagging rainbow and steelhead, a commercial fisher recovered a tag from a post-spawning female steelhead caught on the Copper River Delta, near Cordova, 19 days after it was tagged and released more than 200 mi upstream at Hungry Hollow Creek.

Future research in the Gulkana should strive toward improving knowledge on life history and seasonal range of resident rainbow trout so that the estimation of stock abundance may proceed. Moreover, it is known that rainbow and steelhead are caught by salmon fishers in areas where the use of bait is permitted. It is unknown if resident trout periodically move between bait and no-bait areas. If the level of mixing is high, e.g. trout frequent bait areas and no-bait areas, existing regulations may not be optimal. If the level of mixing is low, e.g. trout marked in areas allowing bait remain in those areas, then portions of the overall stock may be subjected to greater pressure by the salmon bait fishery. This information might best be gathered using radiotelemetry. Additional information from radio tracking would include the location of other spawning areas within the drainage and overwintering concentrations.

Kaina Creek

Before this study, no baseline data regarding rainbow trout or steelhead had been collected other than an initial site survey in 1961 to Kaina Creek, and field notes on a radio-tagged steelhead tracked there in 1983 (Burger et al. 1983). This study documented spawning resident rainbow trout and steelhead near Kaina Lake's outlet, but was not able to estimate or describe the composition of the population because of small sample sizes. The Kaina system includes a significant quantity of quality habitat for salmonids, and is a producer of sockeye and chinook salmon; which in turn may provide food for populations of rainbow trout, lake trout, Arctic grayling, and burbot. Because of time constraints imposed by flying weather, snow, lake ice conditions, and staff schedules, our survey did not cover as much of Kaina Creek as planned. We surveyed downstream 21 mi to the approximate location where the radio-tagged steelhead was thought to have spawned in 1983 (Burger et al. 1983). Spawning rainbow and steelhead, and completed redds were easily observed from shore, and these fish were vulnerable to angling. Only one other trout was caught away from the outlet, in a location 1.5 mi downstream with numerous redd pits and carcass remains from chinook salmon spawning. Information gained from the survey of Kaina Creek suggest that the 1983 radio-tagged steelhead may have spawned at the lake outlet, but was only detected during its movement to or from there. The remaining 7 mi of Kaina Creek down to Tazlina Lake are believed to hold additional rainbow trout habitat. One ADF&G crew conducted a chinook carcass sampling trip between Kaina and Tazlina lakes and reported that progress downstream was exceedingly difficult with numerous and dangerous log jams and rapids (C. Whitmore, ADF&G, Palmer, personal communication).

It remains unknown whether the trout population is large enough to withstand harvest. It is known that some angling for Arctic grayling and rainbow trout occurs at, and below Kaina Lake during the summer months (Mr. Al Lee, Tolsona Lake, personal communication). Low-level sport fisheries at Kaina Creek and Lake have been suggested by unpublished estimates of annual effort, and catches and harvests of trout from the Statewide harvest, catch, and participation surveys. We do not know whether greater numbers of fish spawned prior to or following our survey trip, or if angling occurs at the time of spawning. To better understand this, accurate assessment of spawning rainbow and steelhead stock size and a clear understanding of effort may be needed. This may be difficult because unlike salmon, existing information on rainbow and steelhead spawning in the Copper Drainage attest to a brief presence at their spawning grounds (Brink 1995, Stark 1999). Moreover, a substantial time commitment would be needed to understand the timing of rainbow and steelhead spawning at this location. However, if the angling window of opportunity is limited, fewer trout may be harvested. If further information on rainbow trout is desired from the Kaina Creek drainage, it would be beneficial to examine the resident rainbow population during times of sockeye and chinook spawning activity above and below Kaina Lake. At present, it will be beneficial to reexamine the existing regulations in small fisheries like Kaina Creek, with special regards to the Cook Inlet and Upper Copper River Basin Rainbow/Steelhead Trout Management Policy.

Hanagita River

During the early 1960's a small sport fishery for steelhead occurred at Hanagita River and Lake. No formal attempts to characterize the population in terms of abundance, size and age, and the incidence of resident rainbow trout were undertaken before this study. Steelhead were caught and sampled at the outlet area of the lake during several ADF&G site visits between 1963 and 1976 (ADF&G *Unpublished a*). In recent years, questions from anglers, angling groups, and pilots from Wrangell-St Elias National Park indicated concern that over-exploitation of this small stock may have occurred. Although we determined that steelhead still return to the Hanagita River and Lake system, we were not able to successfully conduct a mark-recapture experiment to assess abundance. Regardless, the trip to Hanagita Lake and River yielded information concerning the life history which is important to the management of this small stock of steelhead.

This study determined that steelhead continue to return to this site for spawning. Steelhead within the Hanagita study area migrated from the ocean to- or very close to their spawning locations by early fall. This is unlike other documented Copper River stocks, such as the Tazlina and Gulkana rivers, where steelhead continue to migrate significant distances to spawning areas in the spring after overwintering in freshwater. Information gathered from anglers and guides indicated the small run of steelhead starts in early September. We sampled fish from September 11 until September 20. Information gathered from conversations with guides and anglers and from ADF&G files based on brief sampling trips during or before 1976 indicated fish have been present at the lake as early as the first week of September. One previous land owner and fisherman indicated that the steelhead run generally began on or around September 10 (Mr. Howard Knutson, Anchorage, personal communication). The duration of the run is not known since guides and anglers generally do not frequent the area after September 15 to avoid early winter storms.

It is reasonable to hypothesize that the Hanagita steelhead run timing is early fall, or late summer based upon the nature of their final migration. Between the confluence of the Tebay and Chitina rivers and Hanagita Lake, pre-spawning steelhead gain nearly 2,000 ft elevation while migrating 20 mi. Along this stretch of heavy whitewater, the estimated stream gradient may be as steep as 375 ft in one mile of river. It is possible that Hanagita-bound steelhead take advantage of lower flows in late-summer and fall to ascend the river rather than during periods of snowmelt, glacial melt, and high flows.

The low incidence of repeat spawning (1 of 10 ten sampled), based on scale pattern appeared consistent with previous accounts from Hanagita. It may, however, be less than other steelhead stocks. Repeat spawning fish may compose 50% or more of the spawning populations in some locations such as the Situk River near Yakutat (Johnson 1996).

Concerns for the steelhead population at Hanagita Lake came about through a lack of angling reports, coupled with pilots reporting the lack of traditionally seen concentrations of steelhead at the outlet of Hanagita Lake. Williams (1964) reported 35 steelhead in the Hanagita River within 0.5 mi of the outlet between September 12 and 14. Field notes from September 6, 1985 reported 17 large fish (thought to be steelhead) at the outlet and 30 to 40 other large fish (possibly sockeye) schooled in Hanagita Lake at the same time (ADF&G *Unpublished a*). This study found that steelhead did not concentrate at, or immediately downstream of the outlet, but probably pass into and upstream of the lake instead. Although no estimates of abundance were estimated, ADF&G staff and four independent anglers hooked 15 fish and observed as many as five other fish, for a total of 20 fish between September 12 and 20. Some of these may have been observed more than once.

We documented an anadromous range extension of pre-spawning adult steelhead to locations upstream of Hanagita Lake, into the upper Hanagita River during the mid-September study. We captured two steelhead in the river 3 mi above Hanagita Lake, at a location where a local fishing guide had incidentally captured steelhead while fishing for Arctic grayling (M. Williams, Alaskan Northern Adventures, personal communication). Moreover, the same guide indicated that he had angled numerous juvenile rainbow or steelhead near Middle Hanagita Lake. This study suggests that Hanagita steelhead use areas upstream of Hanagita Lake for overwintering and spawning. In addition to holding near the outlet of Hanagita Lake, steelhead have also been reported to hold in the Hanagita Lake adjacent to a creek inlet (one or more channel braids of Lake Creek) along the southwest shore (Matt Williams, Alaskan Northern Adventures, personal communication). Lake Creek's entry to Hanagita Lake, which is evident on 1978 aerial photographs (August 1978 Aerial Photo: 7257 02664 ALK 60 CIR Aug 78) is different to the braided channel seen on current topographic maps (USGS Topographic map: McCarthy A-8, based on 1950 aerial photograph revised in 1966), and different to what was observed in 1998.

It is likely that a shift in preferred steelhead holding areas away from the Hanagita Lake outlet and Lake Creek inlet areas came about through natural processes and not through fishing or associated activities. A previous land owner at Hanagita Lake's outlet reported the outlet as having a predominately rocky bottom (Mr. Howard Knutson, Anchorage, personal communication). Lake Creek now enters directly into the outlet area of Hanagita Lake, and no longer along the southwest shore (as in 1978 aerial photos) or locations further downriver in channels or braids (as current topographic maps based on 1950 photos). Moreover, observations during a brief foot survey indicated that the lower part of Lake Creek's channel was unstable and actively changing course in the floodplain. It is probable that outwash of fine alluvial materials from Lake Creek altered the habitat in the outlet and in areas immediately downstream. Returning steelhead probably move to other places with better cover and depth for holding.

Although apparently suitable habitat exists for resident rainbow trout, none were captured by angling in flowing waters or gillnetted in Hanagita Lake. Previous to this report, no known formal or informal report exists documenting adult resident-form rainbow trout in the Hanagita

River drainage. This and the early run timing attests to the uniqueness of the Hanagita stock. In the future, genetic samples collected in 1998 from Hanagita River steelhead should be compared with other Copper River rainbow and steelhead stocks.

Information from this study that extends the range of steelhead and reports the lack of resident rainbow leads to concerns over existing regulations which allow for the harvest of rainbow or steelhead in areas upstream of Hanagita Lake. Using this information, a proposal was drafted for consideration by the BOF in 1999. This proposal seeks to extend the catch-and-release regulation into and throughout the areas upstream of Hanagita Lake. Current regulations allow for five fish daily with only one fish greater than 20 in. The same proposal would extend the regulation downstream to the Chitina River, where the harvest of Hanagita-bound steelhead is permitted under existing regulations. Extension of the no-harvest regulation would protect migrant, spawner and pre-smolt steelhead and resident rainbow trout when present. Additionally, such a change in regulation would allow greater consistency with the BOF-approved rainbow and steelhead management policy. In the future a spring survey should be conducted to locate spawning concentrations of steelhead and perhaps rainbow trout. This will allow the geographic distribution of steelhead spawning to be documented, and would help detect if resident rainbow trout exist in shared spawning areas. If abundance of the Hanagita River steelhead must be known, it would probably be feasible to use a compact weir or counting fence near the outlet of Hanagita Lake.

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Appendix A
Data File Listing

Appendix A1.-Data File Listing

Data File	Description
1998 Copper Dr Rbt and SH data	1998 rainbow and steelhead data from all sites and times

Data files were archived at and are available from the Alaska Department of Fish and Game, Sport Fish Division, Research and Technical Services, 333 Raspberry Road, Anchorage, Alaska 99518-1599.